THE HONEY ANTS OF THE GARDEN OF THE GODS.

By Rev. Henry C. McCook, D. D.

I.—Geographical Distribution.

The peculiarity in the Honey Ants (*Myrmecocystus melliger*) which has attracted the especial attention of naturalists is that one of the castes or worker forms has the abdomen distended to the size and form of a currant or small grape, and entirely filled with grape-sugar or "honey."

Very little of their habits has heretofore been known, and only the forms of the honey-bearer and worker-major. In order, if possible, to remove this reproach from Entomology, I started in the early part of July, A. D. 1879, for New Mexico, as the honey-ants have been found in the neighborhood of Santa Fe, and even as far north as Abiquiu, on the Big Chama River.[1]

During a brief visit at the cottage of Gen. Charles Adams,[2] of Manitou, Colorado, which is located in the mouth of the Garden of the gods, in the course of some observations made upon the ants of the vicinity, a nest was discovered whose external architecture was new to me. The sentinels were called out by the application of a straw, and their general appearance raised the suspicion that they might be Honey Ants, which, as I had never seen specimens, were known to me only by description. The nest was opened, and the delightful fact revealed that the objects of my search were before me. I thereupon made an exploration of the vicinity, and found that the nests were present in sufficient numbers for purposes of study; whereupon I abandoned my New Mexico outfit, encamped in the Garden of the gods, and began the observations of which the following paper is the record.

Up to the time of my discovery, it had not been known that the Honey Ants were distributed as far north as Colorado. I found no formicaries at any other point in the State, although the opportunity to search for them was limited. There is little doubt,

[1] At the latter point Prof. Edward D. Cope informed me that he had seen them. Dr. Loew and Mr. Krummeck saw them near Santa Fe.

[2] Gen. Adams has recently been widely known by his intrepid venture among the hostile White River Ute Indians, and rescue of their unhappy prisoners, Mrs. Meeker and others, at the risk of his own life. As a recognition of this service he has been appointed Minister Plenipotentiary for the United States to the Republic of Bolivia.

however, that they may be found in favorable locations in the entire southern portion of the state, and perhaps also north of the latitude of Pike's Peak.[1] Mexico, New Mexico and southern Colorado, may certainly be designated as the natural habitat of the Honey Ants. It is probable, however, that they may be found throughout the entire south-western portions of North America, especially the uplands. They will doubtless be found west of the Rocky Mountains, as I have recently found one female of this species among a collection of Hymenoptera sent to Mr. Cresson from southern California.

The following facts can be presented concerning the *vertical* distribution:—

Locality.	Elevation.	Observer.
City of Mexico, . . .	7482 feet,	Llave.
[2] Matamoras, Mex., Brownsville, U. S., . .	50 "	Langstroth.
Santa Fe, ...	7047 "	Loew, Kummeck.
Abiquiu, ...	5930 "	Cope.
Garden of the gods, . .	6181 "	McCook.

It will thus be seen that the points at which these insects have heretofore been found, lie for the most part upon uplands, ranging from 6000 to 7500 feet in height above sea level. Mr. Langstroth's find is recorded as "in the vicinity of Matamoras."[3] If this means the near vicinity, the fact prevents the generalization which one might otherwise have been tempted to form, limiting the ants to the upland, for Matamoras has but a slight elevation.

II.—Nest Sites and Exterior Architecture.

The Honey Ants are domiciled in large numbers throughout the section of country known as the Garden of the gods.

The conformation of the surface here appears to be an important element in determining the habitat of the insects, and deserves a brief notice. The Garden of the gods embraces a

[1] The matter of their distribution is a point to which the attention of entomologists and other naturalists is called, and any information bearing thereupon will be of value.

[2] I could not lay hands upon the elevations of Matamoras, which cannot vary much from that of Brownsville, Texas, on the opposite side of the river.

[3] "Proceed. Acad. Nat. Sci. Phila.," vol. vi, 1852, p. 71.

space of about two miles in length by one in width, the surface of which is broken into ridges crossing each other at various angles, and crowned or bordered at the top by the red sandstone and conglomerate rocks, whose peculiar shapes and likenesses to heathen deities have probably suggested the name given to this bit of landscape. A rude idea of the topography may be had by drawing a horse-shoe, the toe toward the north; within the mouth of this let a second horse-shoe be described, occupying about one-half the space in width and one-third in length. Unite the toes of

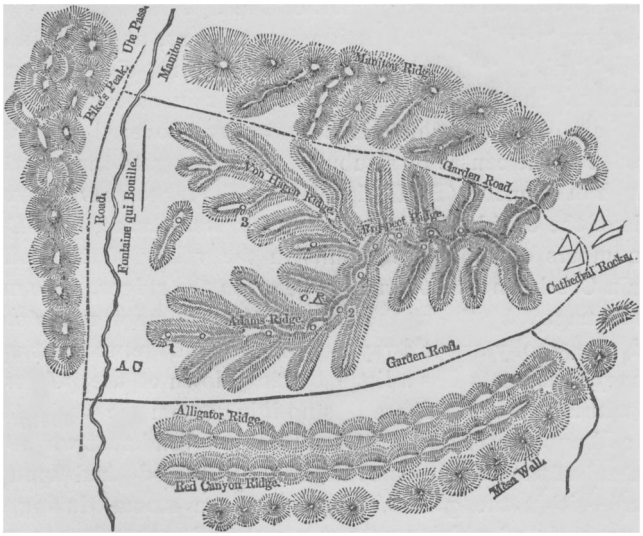


FIG. 1.—Sketch-map of the Garden of the gods.

the two shoes by a zig-zag line, and draw lines east and west, on either side from the interior figure. The western line of the outside shoe will represent the Manitou ridge, which starts at the base of Pike's Peak. The eastern line will indicate the cretaceous wall of the table-land known as the Mèsa, and the two walls of the Red Canyon. The inner shoe has for its western line the Von Hagen ridge, for its eastern the Adams ridge; the east and west lines will represent the general course of the ridges which drop down from these two, from the broken central ridge, Prospect ridge, represented by the zig-zag line, and from the eastern face of Manitou ridge. These ridges are composed of red sandstone, which crops out freely, forming vast ledges and cliffs. The top soil, where the rock is not exposed, is a heavy gravel, upon which grow tufts of gramma grass, straggling bunches of grease wood,

Spanish bayonet, low cedars and pine, and in the little vales or nooks wild sunflowers, wild roses, and numerous small thickets and clusters of a scrub oak (*Quercus undulata*). These localities are indicated diagramatically in the sketch-map at Fig. 1.

All along the tops of these ridges, and on the eastern and south-eastern slopes, the nests of the Honey Ants are located (Pl. I, fig. 2 [1]). About ninety per cent. of those found were on the tops of the ridges, and every one on or near the summit or central line of the top. The choosing of such a site may, therefore, be inferred to be a fixed habit of the ant.

The advantage of this location is apparent, at least in the points of dryness and warmth. I made several observations of the effects of the heavy July and August rain storms upon the exterior architecture, which is a low, gravel-covered moundlet, penetrated at the centre by a tubular gallery or gate three-fourths of an inch in diameter (Pl. II, figs. 3, 4). The large gravel-covered mounds of the Occidental Ant (*Pogonomyrmex occidentalis*, Cresson), numbers of which were built in the valley of the Boiling Fountain Creek, and in the nooks between the ridges, were more or less damaged by the wash of the water. Some were seriously injured, one wholly swept away. The only damage wrought upon the Honey Ant nests was a little beating down of the pellets of gravel within the gate. There was no injury from the wash of the water, and apparently no likelihood of any beyond that which the momentum of the rain-drops could inflict as they dashed upon the nest and within the gate. Throughout one storm, during the entire progress of which a nest was watched, several ants were stationed like sentinels within the gate around the upper margin (Pl. V, fig. 25). They were evidently on the look out for any damages to their home. The disarrangement of a few pellets moved two of these sentinels to bring up bits of gravel and attempt repairs. But there was little occasion for this, although the force of the rain was great enough to cause a good deal of discomfort to the observer. In half an hour the rain ceased, the sun came out over Pike's Peak, and a rainbow girdled the Mèsa. One worker-major crawled upon the crest of the nest, stretched herself, reared her head as though to snuff the fresh air, then

[1] This is a sketch of my camp, from the point at which the Adams and Von Hagen ridges meet. One of the ant-nests is seen in the foreground; others are indicated by the white circles on the crests of the ridges.

hurried down the gravel side and started at a swinging pace along the trail to a neighboring oak copse. An hour afterward she had not returned, and not another ant had left the nest. Several, however, came out, but apparently were disturbed by a gale which followed the rain, and returned.

On another occasion, the slight disarrangement of the nest made by the rain was repaired immediately after the storm. It amounted to a closing up of the greater part of the entrance by some of the displaced gravel-stones along the crater.

The exterior architecture has been referred to as a small moundlet of gravel.[1] The largest seen was one on one of the ridges quite within the Garden; it measured around the base thirty-two inches, in height three and one-half inches, length of northern slope four and one-half inches (Pl. II, fig. 3). The average dimension of the nests is something less than this. The base diameter varies from ten to three and one-third inches, the greatest number of nests measuring six and seven inches.[2] The ordinary height is from two to three inches. The shape of the nests is a truncated cone. The section across the top is about two inches in diameter. In the centre is a tubular opening or gate, from three-fourths to seven-eighths inch in diameter.[3]

III.—Position of Honey-Bearers in the Nest.

Leaving the details of the architecture to a later period, that habit which attaches the greatest interest to this insect, viz., the storing of honey, may be considered. The first nest that was opened, and called the "Bessie" nest,[4] for convenience of notation, is on the terminal slope of Adams' ridge, looking due south, and quite near to the valley of the creek Fontaine qui Bouille. The gravel had

[1] Dr. Oscar Loew, "American Naturalist," 1874, says of Melligera collected near Santa Fe, that "they make no hills, like other ants." "A structure like a crater indicates where they live underground." Every formicary seen by me had a decided elevation.

[2] I succeeded in bringing one of these mounds home nearly entire, having fixed the gravel contents by liquid cement.

[3] Dr. Loew says of the nests near Santa Fe, that the openings were the size of a quill. It seems strange that such a difference should exist within localities so near each other.

[4] A little girl, Bessie Root, a guest in Gen. Adams' cottage, whom I had enlisted in the search for ant-hills, first reported to me the nest in which I found the Melligers.

not been penetrated to a depth of more than six inches before a honey-chamber was uncovered, and the presence of the honey-bearers indicated that a home of the true Honey Ant had been found (Pl. III, fig. 5). Within a dome-roofed vault, about three inches in width and three-quarters to one inch in height, hung the honey-bearers, clinging by their feet to the roof. Their yellow bodies stretched along the ceiling, but the rotund abdomens hung down, almost perfect globules of transparent tissue, through which the amber-colored honey showed. They looked like a cluster of small Delaware grapes or large currants. Most of the abdomens were quite round, but they were in various stages of fullness. Upon some the external membrane of the abdomen was gathered in folds. A few of the abdomens, and especially those but little distended, were of a white instead of amber color.

I have observed that the honey-bearers in my artificial nests show the honey, which has been gathered from white sugar, quite white and translucent. It is probable that the color becomes amber, and even a wine color, with age. When the abdomen is full it fairly shines, reflecting the light that falls upon it from the lamp. With most of the honey-bearers the abdomens hang downward without touching the ceiling, except at the rotundity near the base, and often not even at that point. With some, however, the whole lower part of the abdomen rests against the roof (Pl. IV, fig. 13). This appears to depend chiefly upon the contour of the perch, and not upon the relative degree of comfort to the ant in the two positions.

The roof of the honey-chamber is different in structure from the floor, the latter being comparatively smooth, while the former is rough, being the natural granulated surface left after the picking away of the sandy soil. This character, of course, enables the honey-bearer to cling more easily and securely to her perch. This position is not held by the mandibles clasping the rugose dome with their sharp teeth, but almost exclusively by the feet, whose claws, hairs and pulvuli all doubtless contribute to the effect.

Judging from observations upon artificial nests and from the utter unwieldiness and helplessness of the fully charged bearers, they are not much disposed to change their roost after once taking it, at least after they have reached a considerable degree of rotundity. But the statements generally made by writers, that they are wholly unable to move, and never change position, are

inferences without the facts. They are not unable to move, and in point of fact do occasionally move their positions. Those whose abdomens are but half or even two-thirds the full globose, I have frequently seen coming out of their chambers, ascending the galleries and moving freely about the surface. Those with full globes can move about with no little agility when placed upon a table, or when exposed in their nests to some unusual danger or alarm. In the nests they slide along from point to point, moving their feet sidewise, and so make changes of position.

Fallen Honey-bearers Helpless.—If once they loosen their hold, however, and fall to the floor, they seem ordinarily helpless to recover. Numbers of my full honey-bearers dropping from various causes, or shaken down by thoughtless visitors, laid upon the floor helpless, resting upon the rotund abdomen, bodies up, antennæ and feet in motion, and seeming exceedingly uncomfortable. Those who so fell as to have some object upon which to lay their feet, as a clod or the surface of the jar, fared better. In very favorable positions a few recovered their roost. But as a rule they were helpless, remained stationary, and so passed their lives, which were evidently shortened by their position, although some of them lived thus several months (see Pl. VI, fig. 32).

IV.—Source of Honey-Supply.

The rotunds do not elaborate the honey, as has frequently been asserted. I was not for a moment misled by this fancy, being satisfied that, in the nature of things they were sedentary, and that their immense abdomens were charged by regurgitation from the workers who were the honey gatherers. But whence do they obtain their supplies?

Not from Aphides, at this season of the year at least. I searched every bush and shrub in the vicinity, including large numbers of wild rose bushes, but failed to find any of these familiar and useful Emmet "herds." Certainly, at least, the honey ants were not there drawing supplies from them. It was not possible to trace the ants to these or other sources of food supply during the day, for I found very soon that they were nocturnal insects. Their nests were as silent, and to all appearance empty, as an abandoned habitation, during the daytime. I accordingly stationed myself beside a nest to await the nightfall. This nest was located upon the summit of a ridge which from a peculiar formation of a

rock upon it I named Eagle-head ridge, and the nest Eagle-head nest. At 7.30 P. M., the sun was set, and darkness had begun to gather. A few ants appeared within the gate. They advanced to the top, followed by others; they pushed out upon the gravelled sides of the mound, over which a goodly swarm of yellow insects was soon gathered. There were no rotunds or semi-rotunds among these mustering squadrons; all were workers, with normal abdomens.

Presently an ant left the mound and started over the ridge northward. Another—several—a score followed, until within a brief time a vast column was seen trailed along the ridge, all moving in the same direction. The evening had now become so far advanced that it was difficult to trace the column, but by stooping down close to the earth and using care not to alarm the ants, I was able to do so. The trail was somewhat winding, but on the whole seemed to be chosen with some regard to avoiding the inequalities of the ridge. I was not impressed, however, with the engineering skill of the insects in this matter.

At the distance of about fifty feet from the nest, the column turned down the slope and entered a copse of scrub oak (*Quercus undulata*, var.). I traced a number of ants to a bush several feet within the thicket, but failed to unravel the secret that night. The next night a similar experience awaited me. After a long, careful, but vain search, I retired to my tent baffled. The third night (July 29), the ants of Eagle head next came out at 7.23 P. M. Those on Toad-stone ridge, to which I had assigned my assistant, Johnson, came out at 7.25 P. M., but did not begin to move until 7.44. Johnson followed them, but failed to find their feeding ground. They moved north and eastward, as did those of the Eagle head. These latter began to move almost as soon as they came out. They followed the same trail as on the previous evening, the track having beem marked by me. The movement was somewhat slower than before, perhaps because the trail had been washed by a heavy rain during the afternoon. There was no leader. A dwarf worker kept in advance over the greater part of the track, then a worker minor took the head of the column. The two were separated from each other, and the van of the column about eight to ten inches. There was, however, not the slightest evidence of any leadership at any time, in any part of the moving line, although I carefully looked for such.

The ants directed their movements to the same tree as on former forays, reaching it in seventeen minutes, at 7.40 P. M. They distributed themselves along the tree, hunting trunk, branches, leaves. I could trace their forms, but when it is remembered that I was wedged in among the thick, low branches of this dwarf oak, holding up a lantern with one hand, and using the other to clear space for it; that the necessity to avoid alarming the timid insects compelled me to retain very inconvenient positions for a long time, it will not seem strange that I could find nothing satisfactory until between nine and ten o'clock. At last, in course of the slow investigations, I reached the extreme end of a branch on the south side of the tree, and found a number of ants engaged upon clusters of brownish-red galls. The ants were moving from gall to gall, not tarrying for any length of time upon any. They applied their mouth organs to the galls frequently. The dimness of the light, and the distance which I was compelled to keep, prevented me from seeing anything more than this. But it was plain that they were obtaining honey stores, for in the lantern light it could be seen that their abdomens were already much distended by the sweets which they had lapped.

The branch was carefully cut off without disturbing the ants, taken to my tent, and the movements of the insects observed during the remainder of the night, the branch having been so placed as to prevent the escape of the ants, who were yet easily under view. They, however, were so preoccupied with their honey gathering, that they made little effort to escape.

Directing attention to the galls, it was seen that some of them were gradually exuding minute globules of a white transparent liquid, which the ants greedily licked. I tasted the liquor, and found that it was very sweet and pleasant. The object of the nocturnal expedition of the ants, and the source of their honey supply, were thus revealed. These galls are of various sizes, from that of a currant downward. Most of them were of a Turk's-head shape, some flattened spheres. They are placed in groups of two and more along the stems of the branches; they are commonly of reddish-brown color, marked with black patches, but some of them are of a brighter tint, almost rose-color, some of a livid yellow marked with black, some almost green. By cutting off a few of the clusters and removing them from the ants, I saw that the sugary sap issued from several points upon the gall, which in some

cases became beaded with six or more globules, several times larger than a pin-head. By removing these beads successively, I found that during the night one gall gave out at least three series. The continual flitting of the ants from branch to branch and gall to gall, was thus explained: the successive exudations invited their frequent return to the galls from which they had formerly fed. When the branch had first been brought to the tent, some of the gall-bearing twigs had been clipped off and placed within the artificial nests, but received no attention from the ants. Some of the bleeding galls were now introduced, which were instantly covered by the ants, and soon cleaned of their beaded sweets. An examination of the first galls explained the reason for their neglect—they were sapless.

NECTAR-PRODUCING GALLS.—A number of galls of various sorts and sizes, was collected for dissection. They were readily divided into two classes (1), the livid and greenish galls which were soft and entire; (2) the darker colored ones which were hard, unyielding to the touch, and pierced at one side by a small, smooth, regular, cylindrical cavity. It soon appeared that the bleeding of honey-sap was confined to the first class. Upon cutting away the soft pulpy fruit (if it may be so termed), a hard whitish-green ovoid cell, not unlike a cherry seed, was found at the centre. It was about one-eighth inch in diameter. Lying outside of and against this, in a little cavity, I found in one gall a minute, living grub (Pl. III, fig. 12). The body was white, of eleven segments, the head tipped with a brownish hue. The inner cell when opened, showed a spherical cavity in which was a very minute gelatinous pyriform object, which adhered to the side of the cavity. I had no microscope with me, and in lieu of facts, can only conjecture that this may have been an embryonic form of an insect, which matures later in the season.

The hard galls were next dissected. They are all pierced on one side, invariably near the base (figs. 10, 11), by a circular opening made by the matured gall-insect in its escape. Fig. 11 represents one of these, a turban-shaped gall, magnified about three times the natural size. A section view of the gall (fig. 10) shows that the exit hole (*eh*) penetrates the interior cell-case, which must therefore serve as the cocoon in which the pupa transforms. Inside of some of these cells I found traces of a flossy texture. The cells are commonly spherical, but (as in fig. 10) sometimes

egg-shaped. They are separate from the rest of the gall, from which they quite differ in appearance, and are of a firmer substance. In fig. 10, the gall is three-sixteenths of an inch in length, of which the cell occupies two-thirds, that is, one-eighth of an inch. The largest gall observed had an outside measurement of three-eights inch long and the same across the top. In one of the galls opened, I found an imperfect insect (imago), which is identified by Mr. E. T. Cresson as of the genus Cynips, a true gall-fly. The specimen would not permit further identifitification.

At the meeting of the American Association for the Advancement of Science, held in 1880, at Boston, I had the pleasure of presenting the substance of this paper to the Entomological Section. My account of the extravasation of the galls, as above, caused much comment, the result of which was to confirm the accuracy of the observation which had been challenged. Prof. C. V. Riley, well known as an entomologist, declared upon his own observations, that many galls exude saccharine matter, citing among others, those of certain Phylloxeræ on Hickory, one of which he had named *caryæ-gummosa* on account of the abundance and stickiness of the exudation. Mr. H. F. Bassett, who has made extensive and careful studies of galls, said that he had found many species of galls visited by ants [1]

Specimens of the oak-gall visited by Melliger were sent to Mr. Riley, concerning which he says: The gall is one that is found quite commonly in the Rocky Mountain region on *Quercus undu-*

[1] American Entomologist, Dec., 1880. The following additional remarks will be interesting in this connection: Mr. E. P. Austin remarked that the chemical composition of sugar and woody fibre are the same, and that sugar could be produced by conversion from woody fibre in the plant. Dr. J. L. Le Conte said that he understood tannin to be a conjugation of gallic acid and sugar. Mr. B. P. Mann suggested that some light might be thrown upon this food-supply of the ants, by the nature of much of the moisture which appears occasionally at night in great abundance on the leaves and other portions of plants, and which is usually mistaken for dew. This moisture, it is said, differs from dew in being produced under circumstances which would not account for the formation of dew, and in containing a perceptible quantity of sugar. It is the ordinary watery excretion from the surface of the plant, which, under favorable conditions of the atmosphere, collects in beads or in drops, instead of evaporating as rapidly as it is formed.

lata, as determined by Dr. Engelmann, who sent me the same gall in 1874, though I had previously collected it myself. It is, undoubtedly, an undescribed gall, and a very similar one occurs on the *Quercus macrocarpa* in the Mississippi valley. It has the ordinary woody texture that belongs to so many Cynipidous oak-stem galls, and the architect develops in a paler cell that occupies a large part of the interior of the gall. When fresh, the gall is quite bright-colored, inclining to crimson or scarlet. It seldom attains a larger size than an ordinary pea, and differs from similar galls in my cabinet by having frequently a rather broad, flattened crown, though this character is by no means constant.[1]

NOCTURNAL HABITS.—It has already been said that the ants collect the oak-gall nectar by night. Observations daily repeated upon a number of nests, determined that they leave their nests for the oak thickets at or near 7.30 o'clock P. M., and between that hour and 8 o'clock, which is about the time of sunset in July and August. Previous to the departure, the crater, gate and exterior of the mound become gradually covered with swarms of insects whose yellow bodies quite hide the red gravel surface of the nest. The marching of the honey-gatherers has already been described, but always there remained a very numerous force at home, who were seen at all hours of the night on guard within and around the gate. (Pl. V, fig. 25.) The return home began about or a little before midnight, and continued until between four and five, which was near daylight at that season. One or two extracts from my field notes will indicate the facts on this point. "11.30 P. M. Some ants returning home; the movement very slow and deliberate. . . . 12.30. Quite a number are now returning. Some are also still going outward. Numbers of workers patrol the mound and vicinity challenging nearly all incomers, who have to stand the test and give the required satisfaction. What is the antennal password? None of the returning repletes are tolled by the home sentries. . . . This morning at 4.10 A. M. the ants were seen coming in from the oak bushes, most of them well laden, but others not so full. There are evidently degrees of success in honey-gathering among them. Some of the dwarfs had very full abdomens. . . . 4.30 A. M.

[1] He suggests for the gall the name *Cynips quercus-mellariæ*. Am. Ento, Dec. 1880.

The ants are returning in numbers and rapidly moving from the brush to the nest. It is about daylight."

In these night observations the light of the lantern seemed to cause the ants in column no little disturbance. They would go toward the lantern as it sat on the ground near the trail, appear to examine it, then move away. It really seemed to confuse their ideas of locality, and shake their confidence as to the site of the trail, although no one was finally thrown off the track thereby. The sentries at home were always more or less excited by the light, and delicate manipulation was everywhere required in order to preserve the natural conditions and get the natural behavior.

At no time were the ants seen during the day except when it rained, and then only a few sentinels appeared at the gate. Ordinarily the entrance, as far as the eye could see, was entirely abandoned. It is doubtful if Melliger can endure a great amount of sunlight and heat. While excavating a nest, a number of specimens were collected in a large empty glass bottle, which was set aside for further use. Not more than three minutes afterward when I took up the vessel to insert more specimens, those already collected were dead. The sun had killed them. I was surprised at this quick fatal issue, and tried to revive the insects; but no, they were quite dead. The sun was of the usual August temperature, but the bottle was large, and such a result in so brief a time argues extreme sensitiveness to the heat. I have observed that the agricultural ants[1] always avoided the noonday heats of Texas, which are certainly intense; and indeed all ants appear to me to shun, more or less, the midday fervor of the sun. But Melliger doubtless is more susceptible to solar influences than most of her fellows. It cannot therefore be wondered at that she seeks her food under the shelter of night.

V. Quality of the Ant Honey.

A number of the honey-bearers were unavoidably injured and their abdomens broken during the excavations of the nests, and I observed from these the quality of the honey. It is very pleasant, with a peculiar aromatic flavor, suggestive of bee-honey, and quite agreeable to me. Dr. Loew describes it as having "an agreeable taste, slightly acid in summer from a trace of formic acid, but perfectly neutral in autumn and winter." It contains, according

[1] Op. cit., p. 18.

to this writer, a little more water than the honey of bees, and has therefore somewhat greater limpidity.

Fortunately, the composition of this ant-honey has been subjected to a thorough chemical analysis by a competent authority, Dr. Chas. M. Wetherill.[1] The experiments were made at the request of Dr. Leidy, from specimens of *M. melliger-mexicanus* collected by Mr. Langstroth at Matamoras, Mexico.[2] These ants showed the variations observed by me in the distension of the abdomen, and the amount and color of the honey. Six of the average-sized honey-bearers were weighed, and showed the average weight of the honey-bearer's body alone (without honey) to be 0·048 grammes, and the average of honey in a single ant 0·3942 grammes. The amount of honey was therefore 8·2 times greater in weight than the body without the honey. The density calculated for the ants filled with honey was 1·28, and for the bodies alone 1·05. Dr. Wetherill's calculations expressed in English Troy weight would allow about six grains for the weight of each honey-bearer. It would thus require about one thousand (960) honey-bearers to yield one pound of honey (Troy weight), or about twelve hundred (1166) to yield a market or avoirdupois pound.

The syrup extracted from the ants had an agreeable sweet taste, and an odor like that of the syrup of squills. When set aside as removed it showed no trace of crystallization to the naked eye or under the microscope. Under high powers fragments of organic tissue were seen. When evaporated by the heat of steam, it dried to a gummy mass, which did not exhibit traces of crystallization after standing for a couple of weeks.

This mass was very hydroscopic, becoming quickly soft from the absorption of water from the atmosphere. It dissolved without residue in ordinary alcohol, leaving a residue in nearly absolute alcohol. These solutions did not crystallize when set aside. They had exactly the smell of perfumed bay rum. After various tests, which are described, Dr. Wetherill analyzed by combustion with oxide of copper and chlorate of potassa a portion of the gum-ke substance which resulted after the ant-honey had been left in vacuo for two weeks. As this was not perfectly hard, but of a sticky nature, it was necessary to introduce it into the combustion

[1] Proc. Acad. Nat. Sci. Philad., Vol. VI, pp. 111, 112, 1852.

[2] I have some of these still in good condition after twenty-nine years' preservation in alcohol.

tube upon a piece of glass. 0·497 of honey gave 0.306 of water, and 0.684 of carbonic acid, corresponding to a percentage of C = 37·535, H = 6.841, O by loss =55:634. This corresponds, as nearly as could be expected under the circumstances of tho analysis, with the formula of crystallized grape sugar, C_{12} H_{14} O_{14}.

Dr. Wetherill, who in this analysis was especially seeking light upon the origin of the ant-honey, thus announces his conclusion: "It results, I think, from these experiments, that the honey contained in the Mexican ant is a nearly pure solution of the sugar, so called, of fruits, which is in a state of hydration, isomeric with grape-sugar, C_{12} H_{14} O_{14}, and differing from grape-sugar in not crystallizing." It is certainly an interesting confirmation of the value of this reasoning from analysis, that the ants have been proved by field observations to have collected their honey-dew as Dr. Wetherill concluded, from the nectar of plants. Thus the methods of cabinet and laboratory, and the objective studies of the field, confirm and complete each other.

With regard to the acidity of the ant-honey, which has been referred to, Dr. Wetherill found that it reacted slightly acid to blue litmus paper, but want of material prevented satisfactory experiments. He was in doubt as to whether it was formic acid, or acetic from the oxidation of the alcohol in which the ants were preserved. A portion of the alcohol (reacting acid like the honey) neutralized by caustic potassa, when distilled with sulphuric acid, gave an aqueous acid liquid, which, on addition of nitrate of silver, gave a whitish precipitate, becoming black on boiling, rendering the supposition of formic acid probable.

The uses to which the Mexicans and Indians put this ant-honey are various. That they eat it freely, and regard it as a delicate morsel is beyond doubt. Prof. Cope, when in New Mexico, had the ants offered to him upon a dish as a dainty relish. The Mexicans (Loew) press the insects, and use the gathered honey at their meals. They also are said to prepare from it by fermentation an alcoholic liquor. Again, they are said (Edwards) to apply the honey to bruised and swollen limbs, ascribing to it great healing properties. Dr. Loew's suggestion to bee-keepers to test the commercial value of these ants as honey producers is wholly impracticable. The difficulties of farming the colonies, gathering the supply, and the limited quantity of the product, would prevent a profitable industry. The greatest number of honey-bearers in a

large colony, taking my observations as a standard, will not exceed six hundred, which, counting six grains of honey to the ant, would be little more than one-half pound avoirdupois. Besides, the sentiment against the use of honey thus taken from living insects, which is worthy of all respect, would not be overcome. The Mexicans and Indians will therefore probably not be disturbed in their monopoly of the honey-product of the nests of Melliger.

VI. Interior Architecture.

Gate Architecture.—In order to determine the gate architecture—a term by which I characterize the structure of the nest nearest to the entrance—several formicaries were carefully opened and studied. Four of these are here given as fair types of all. It will be seen from these that a general similarity of plan prevails. The gate itself is a single tubular opening in the centre of the mound, from three-fourths to seven-eighths of an inch in diameter. It is smooth within, and penetrates the mound and the earth perpendicularly to a depth varying from three and one-half to six inches. This gate is funnel-shaped at the top, and the funnel (Pl. IV, fig. 14, F) is gravel-lined, differing therein from the lower part or nozzle of the gate (fig. 18, N). The nozzle descends perpendicularly, or with a slight slope, for three inches, more or less, and then deflects at an angle more or less abrupt, forming an arm (A) usually shorter than the nozzle. This leads into a series of radiating galleries and rooms, and the point of deflection may be called the vestibule, V. These galleries and rooms appear to extend quite habitually beneath and chiefly in one direction from the gate. There are indeed galleries immediately surrounding the gate on every side; but these appear to be limited except in the one direction, within a radius of about eight to ten inches, and to the same distance in depth.

These general statements may be illustrated and expanded by the following details of particular nests.

1. Nest No. 7, fig. 19, was a small nest three and one-third inches in diameter. The gate had a perpendicular depth from the surface of three inches. Thence at nearly a right angle it bent south-east for two and one-half inches, forming the arm, A, and meeting at V a series of branching galleries, *a*, *b*, *c*, *d*. Gallery *a*, bore westward, terminating under the gate; *b*, bore southwest, appearing to run upward toward the surface; *c*, extended down-

ward and southward at a sharp inclination, entering a long room. E, was a small circular chamber, at one end of which was a beautiful gallery, *f*, running deep downward and inclining slightly west. It was entered near by and above by another gallery, *d*, running toward the surface.

2. Nest No. 6, fig. 18. The depth of the gate, G, was three inches; the length of the arm, A, two inches. The gallery into which A opened toward *b*, divided at one end with two branches separated at their mouths by a little column of two stones resting one upon the other. The gallery, *c*, could be traced at least six inches downward, and a gallery opened directly downward at *a*.

3. Nest on Eaglehead Ridge, Pl. V, fig. 20. This nest, from which many of my night studies were made, was finally opened, and the section view, fig. 20, taken. The vestibule, as in the above examples, also opened into a main gallery, *b*, which led to the northeast, and joined a circular gallery which passed around the vestibule and terminated in an oval room, A. At the other end it entered a circle, which widened upon one side into a bay-room, and sent off a couple of branches, one of which, *c*, was a chamber. Two galleries, *g g*, opened downward. Beyond this, southward, was a long waved gallery, D D, which ended at *e e*, and branched at *h*. Galleries, *g g*, in this series, also led downward.

No. 4. Fig. 23, Nest No. 4, on Adams Ridge. The diameter of this mound was three and one-half inches at the top and seven inches at the bottom. The vestibule sloped eastward from the summit, downward three inches to the main gallery, which had three branches, *x*, *y* and *z*; *x* was followed six inches northeast and upward; *y*, extended southwest and downward; *z*, southeast and downward. A gallery, 1, ran upward from *z*, and connected with *x*. Another, 2, opened on the southwest into a room, A, six inches long and three inches wide, at the west end of which were galleries dividing north and south. A third gallery separated from *z* at 3, and bent northward, apparently uniting with a room, A, five inches long. This room was entered again by a widened mouth, B*e*, about one-half inch above *z*. At the vestibule and upper part of *z* were a number of cocoons. The room, *A*, was five inches below the surface of the ground at G.

GALLERIES AND HONEY-ROOMS.—The last figure gives an idea of the relation of some of the honey-rooms to the gate and the upper series of galleries. These rooms lie at least as near to the

surface as six and eight inches. They vary in size, but for the most part, are about five or six inches in length and three or four in width. They are irregular in their outlines, but have a general tendency toward the oval. One of the most irregular is figured at Pl. V, fig. 21, HR, a large chamber which lay nearly underneath the gate. The gallery, *g g*, into which the vestibule opened, debouched into this room, and a portion of the gallery roof unbroken is shown at *ug*. At B, appeared a bay-room, or enlargement of a gallery, which penetrated the earth horizontally at one end and at the other seemed to wind into the vestibule. The height of the rooms at the walls or sides is from one-half to three-fourths of an inch. The roof is vaulted, thus causing the height to increase gradually until at the centre it is one and one-half inches, which is the greatest distance that I measured.

Floors and Roof.—The floors and walls are well nigh invariably smooth, quite smooth some of them. The roof, on the contrary, is rough, presenting the natural condition after the sandy pellets of earth and the little pebbles had been picked out by the workers. This can hardly be otherwise than by purpose, precisely as with the smoothness of the floors. The roughness of the roof evidently greatly favors the use to which the honey-bearers put it as a perch. So the smoothness of the floor and walls much better adapts them for the use of gangways. The amount of travel to and fro must be enormous, it is true, in a large formicary; but I cannot think that the resulting friction will account for the smoothness, independently of the purposed masonry of the ants. In the galleries the entire surface, above and below, is smooth, a condition which might be anticipated on the ground of adaptation.

Galleries and Rooms.—The galleries are tubular openings, varying somewhat in size, from one-half to three-fourths of an inch, and even more, in diameter. A vertical section, however, uniformly shows a quite perfect circle. The underground formicary may be described in general terms as a system of galleries and rooms, arranged in several horizontal series, one above another, approximating the order of "stories" in a house, and intercommunicating at many points by vertical galleries. The character of the interior architecture can, perhaps, be best shown further by giving somewhat in detail my studies of one nest.

The nest selected for exhaustive exploration was situated upon the summit of Adams Ridge, just above the nook within which my

camp was located. Three entire days, besides other portions of time, were spent in this work by myself and assistant. The nest interior sloped eastward, and toward the base of the hill, and occupied a space (in round numbers) eight feet long, three feet high and one and one-half feet wide, the whole tunneled through the soft red sandstone rock of which the ridge consists. This rock is much of it quite friable, crumbling readily under the pressure of the hand, but packs tightly under the stroke of mallet and chisel, thus making difficult mining for men if not for ants. Most of our work was done with the chisel, and the galleries and rooms had to be worked out with knives.[1] These thirty-six cubic feet of rock were fairly honeycombed by the series of galleries and chambers above referred to.

The dimensions of the exterior nest are as follows (see Pl. IV, fig. 15): Height, north side, $2\frac{1}{2}$ inches; west side, $1\frac{5}{8}$ inches; east side, $1\frac{7}{8}$ inches; south side, $1\frac{7}{8}$ inches; distance across the top, $a\ c = 10$ inches; distance around the base, $a\ i\ e\ c = 29$ inches; distance around the crater, $m\ o\ n\ r = 8$ inches; eastern ridge of the crater, $v\ n = 1\frac{1}{8}$ inches; western ridge of crater, $m\ s = \frac{1}{2}$ inch; distance across the gate at $x\ z = 1$ inch, at $s\ v = \frac{7}{8}$ inch; depth of the gate before bending, 4 inches. The mouth, as appears from measurement, was ovate (Pl. IV, fig. 14), but the entrance beyond was a circular tube.

The mound was removed and the soil carefully scraped away. Close to the surface, at the distance of one-half to three-fourths of an inch, openings were found of various sizes, from one-fourth to one inch in diameter. These openings occurred at various distances from the gate, on all sides, four and one-half, five, five and one-half, eight, eight and one-half inches and upwards to ten inches on the northwest side, eighteen inches on the south side, and eighty-two inches on the southeast, in which direction the formicary extended. Toward the termination of the nest, however, they did not appear so near to the surface.

Section views were next had by cutting across the nest. On the north side I found no galleries at a greater depth than eight inches. On the south side, the first cutting was made east and

[1] While engaged upon this part of my work, I was pleasantly surprised by a brief visit of Prof. A. S. Packard. I am glad to be able thus to refer to his valuable testimony in confirmation of some of the statements of this paper.

west, and thereafter the rock cleared away outwardly, until the end of the nest, when the cutting was made inwardly from the starting point toward the gate. The character of the architecture is the same throughout the entire nest, so that the following views will suffice to typify all the interior. The figures Pl. VI, fig. 35, and Pl. V, figs. 16, 17, give views of vertical and horizontal sections made from the gate (southeast), the bottom of the section being twenty-one inches below the surface and the distance of the furthest point from the gate twenty-three and one-half inches. Fig. 35, Pl. VI, is a front view of galleries looking south, and exhibits a surface about seventeen inches in length by seven in height.[1] The main series of galleries within this area are accurately shown, but the connecting vertical galleries were broken away in the excavation, and are not figured.

Fig. 16 is a vertical section showing the southwest and southeast sides of the excavation at the same point as the preceding figure, part of which is included in this view.[2] There are here shown the general tendency of the galleries (*g*, *g*, *g*) toward stories, arranged one above another; the relative position of the honey-rooms (R, R), and the relation of the series to the large honey-rooms, C, D, E, shown fully at fig. 17.

The broken lines, *c l d*, and *e h k*, show a series of rooms, some of which were occupied by larvæ and some by honey-bearers. The large rooms, C D E, Fig. 17, belong to the lowest series, and are figured and described as fairly typical of all the honey-rooms and other chambers. They were carefully uncovered by chisel and knife, and after being sketched, a plaster cast was taken of them, which is preserved in my collection.[3] These rooms were of

[1] Detailed measurements.—*a* to G = 5½ inches; G to *d* = 11 inches; *e* to *f* = 10 inches; *h* to *i* = 11 inches; *k* to *l* = 11 inches; *m* to *n* = 3 inches; *b* to *e* = 2⅝ inches; *o* to *f* = 3½ inches; *p* to *q* = 1½ inches; *q* to *k* = 2⅛ inches; *i* to *l* = 2¼ inches; *o* to *r* = 3¼ inches: *l* to *s* = 6¼ inches.

[2] Fig. 16 measurements.—*a* to *b* = 4½ inches; *c* to *d* = 10 inches; *e* to *f* = 4 inches; *h* to *i* = 4⅛ inches; *i* to *k* = 4⅝ inches; *c* to *j* = 10 inches. The gallery, *j*, appeared to connect upward with the lowest series of rooms, *e f h k*.

[3] I succeeded by vast painstaking and labor in securing a number of fine specimens of the architecture, which were carefully packed in boxes and committed to the Express Company at Colorado Springs. The company received a heavy bill for transportation, and delivered my beautiful and

an irregular oval shape; in length five, three and one-half, and six inches successively (C, D, E), and were of an average width of about four inches. They were not built upon a level, the origin of C, at *b*, being three and one-half inches above the middle point of D, and six inches above the termination of E. A side gallery, *g g*, skirted two of the rooms, and appeared to open upon a fourth chamber at F, which, however, was too much broken in the digging to be identified. Of course, only the floor and part of the side walls of the rooms are shown, but the roofs were vaulted and rough, as already described, and rose to the height of three-fourths to one and one-fourth inches. Within them, clinging to the roofs, were packed the rotunds. The number in each room averaged about thirty; and as there were at least ten chambers thus occupied, the number of rotunds in the nest was certainly not less than three hundred. Of far the greater proportion of these the abdomens were distended to a perfect sphere.

THE QUEEN ROOM.—I had the good fortune to capture the fertile queen of this colony. She was found quite near the extreme end of the formicary, in a nearly circular room four inches in diameter. The series of galleries and honey-rooms which composed the formicary terminated in a single gallery (fig. 22, *g g g*), about eighteen inches long, three-fourths inch wide and one-fourth inch deep. The gallery sloped sharply with the slope of the hill-side on which the nest was made. Near the middle part thereof was the queen-room (C), being seventy-two inches from the central gate and twenty-eight and one-half inches below the surface of the hill. Besides the queen the room contained a large number of naked grubs, callows, honey-bearers and workers. It is not improbable that the queen habitually dwelt in or near this room; but it may be that during the successive attacks upon the nest, the workers bore their queen still further and further from the point of danger until the limit was reached.

Ten inches below the queen-room, the gallery, *g g g*, was continued until it finally terminated in a small circular chamber (E) or bay on the one side, and on the opposite side a narrow gallery (*t g*), which curved upward. This was the end of the formicary.

costly specimens at the Academy broken in pieces! It was an act of gross carelessness, which merits this notice, as some specimens brought home in my trunk survived even the "baggage smashers."

It was eighty-two inches from the central gate, forty and one-half inches below the level of the main nest gate, and twenty-nine and one-half inches below the level of the hill-side. The entire length of the formicary from northwest to southeast was thus seven feet eight inches.[1]

VII. Queen Life.

The captured queen of the large excavated nest was transported to Philadelphia, placed in one of my artificial nests, a large glass globe, and afforded several interesting observations upon her habits.

Her Body-Guard.—After the usual custom of ants, she was continually surrounded by a guard of workers (Pl. VI, fig. 29) varying in number, but usually as many as twelve or twenty. These attendants quite enclosed her, and restricted her movements, apparently watching and guarding her with great carefulness. On one occasion when she escaped to the upper surface of the nest, she was followed and seized by a worker-major, who interlocked her mandibles with the queen's (Pl. VI, fig. 26) and dragged her down the gateway into the interior. The royal lady gave only a passive resistance, holding back somewhat heavily.

Depositing Eggs.—I quote from my notes the description of this process, the various stages of which I was also able to sketch. "The queen has been laying a small heap of eggs. She is now on a little elevation of earth, surrounded by a number of workers of all castes, some of whom lick her abdomen, especially beneath and at the apex. One, meanwhile, gives her food in the usual way, by regurgitation. I see the tongues of the two insects overlap in the

[1] While preparing clay models of some of the above examples of ant architecture for my cabinet of Insect Architecture in the Academy of Natural Sciences, it was suggested that moulds be made, from which plaster casts could be taken, for the benefit of such other scientific collections and public museums as they might be wished for. This I had done, and the moulds are now in the hands of the Curator in charge of the Academy, by whom they will be furnished, upon proper order, at the cost of reproduction and packing, as nearly as may be. Five specimens are cast, viz., those figured at Pl. II, fig. 4, and Pl. V, figs. 16, 17, 22 and 23. They are cast natural size, except fig. 16, which is half size. The cost, painted natural color, will be $10 for the set, unpainted $6. Orders should be sent to Charles F. Parker, Curator in charge Academy of Natural Sciences, Philadelphia, Pa., U. S. A.

act. The queen's abdomen is raised high, her head is stooped, she lifts the abdomen up and down. The workers have clustered under her body, giving her somewhat the appearance of a successful candidate undergoing 'a chairing.' She has changed her position; the workers follow, quite surrounding her. Two are beneath the abdomen, which is depressed now, the head being elevated. The attendants sit down patiently to watch. They keep their antennæ moving continually, while they amuse themselves by cleansing their persons. The queen moves; a dwarf seizes a fore-foot and attempts to control her course. This and "nipping" with the mandibles, is the common mode by which the guard directs the queen's motions. The eggs laid are in an irregular mass about one-eighth of an inch thick. There are twenty to thirty minute yellowish, ovoid objects, which adhere to each other. The workers surround the mass, some appeared to lick it. The queen straggles over the eggs, places a foot upon the mass. A dwarf seizes the foot hastily and draws it back, while another worker catches up the egg-mass and draws it aside." The observation was made at 11.20 P. M.; at 1 A. M., when I retired, no change had occurred. This is as much of this interesting behavior as I was able to observe in this female. I have, however, seen the actual deposition of the eggs by a queen of *Camponotus pennsylvanicus*.[1]

VIII. Acts of Beneficence.

In the natural sites the workers showed great interest in the preservation and removal of the rotunds, dealing with them very much as with the larvæ. As the honey-rooms were opened and the rotunds disturbed from their roosts, the workers of all castes rushed eagerly to them, and dragged them into the unbroken interiors. Sometimes several ants would join in removing one rotund, pushing and pulling her along. One sketch (Pl. VI, fig. 27) made in my notes, represents a major pulling a rotund, whom she has seized with her mandibles by the outer abdominal wall, while a dwarf-worker is mounted upon the globe, standing upon her hind legs "a-tip-toe," as it were, pushing lustily. Another sketch (Pl. VI, fig. 36), caught on the spot, represents a worker-major dragging a rotund honey-bearer up the perpendicular face

[1] See a note in "Proceed. Acad. Nat. Sci. of Phila.," 1879, p. 140.

of a cutting made in the excavation of the nest. The mandibles of the two insects were interlocked, and the worker *backed* up the steep, successfully drawing her protégé.

This interest is maintained in the daily life of the formicary. The workers were continually seen hovering about the rotunds as they hung from the roof of my nests, or as they lay upon the floor cleansing their bodies. It is evident that these creatures are regarded as dependents, and, as with the queen, virgin females, males and larvæ, are fed and tended by the active members of the community. In all these cases the same communal instinct would of course control action, giving at least the semblance of beneficence.

Lack of Individual Beneficence.—But a great number of examples fell under notice which go to throw doubt upon the possession of any personal or individual sentiment as towards special cases of need, outside of the above limit. Some of these may deserve permanent record.

1. In making up my artificial nests, I placed in the natural soil, which was closely packed down, and then introduced the ants, knowing that they would work out their own habitations. The honey-bearers were thus mingled upon the surface with the workers, upon whom fell the entire task of digging galleries. In this work, and in the distribution of the excavated pellets, there was much room for the exhibition of individual carefulness and tenderness toward the honey-bearers. Not a single such instance was noted, although I watched closely and with some anxiety to discover such excellencies in my little friends. On the contrary, the exhibitions of an apparent cruel neglect and positive cruelty were many. The grains of sand and soil were heaped around the rotunds (Pl. VI, fig. 31) until the poor creatures were literally buried alive. It would have been easy for the busy masons to draw their fellows aside and thus carry on their work. But it either never occurred to them to do so, or the disposition was wanting.

2. Again, as the openings were made into the earth, most of the rotunds, not prevented as above, managed to roll down the galleries and secure a place in the honey-rooms. They were not observed to be aided in this by the workers, and I believe that they attained their perches unaided. Some of them, on the route, became fastened in the gang-way in most uncomfortable positions,

heads downwards, bodies awry, etc. The workers passed by and over them continually, for many days, without the slightest apparent concern, and certainly without a single observed effort to relieve their comrades, who could readily have been extricated and drawn into the chambers.

3. It frequently happened that the rotunds dropped or were shaken down from their perch against the roof to the floor. These creatures remained in the positions in which they fell, except when they chanced to so fall as to be able to clasp with their claws some clod of earth, or bit of gravel, or the rough surface of the projecting walls or roof. In such case, they either recovered their perch, or placed themselves in comparatively comfortable postures. The greater number, however, fell upon the round abdomen in such wise that the body stood up quite erect (Pl. VI, fig. 32), leaving the legs thrust out unsupported. These unfortunates were faithfully attended, often cleansed and caressed, but in no single instance did the workers attempt to right them and restore them to the roof. Yet they were abundantly able to do so, with little effort, and the fallen rotunds were in sore need of help. Some of these lived for two months and longer in this awkward position, but it was very evident that they were extremely uncomfortable.

When it was practicable to extend my help to those near the surface it was eagerly accepted, the offered stick or quill clasped by the mandibles, sometimes assisted by the feet, so firmly as to enable me to transfer the heavy creatures to any point, even to lift them out of the nest. Here again the idea or at least the act of helpfulness was lacking. If we are to suppose the power of communicating their distress and desires to have been possessed by the bearers, we must think the workers even yet more lacking in feeling and intelligence.

4. One honey-bearer was partly buried under her perch, that portion of the roof having fallen. Her abdomen was quite covered by the fine sandy particles at the margin of the little landslide. The task of rescuing her would have been easy to the workers, but it was never undertaken. A sketch (Pl. VI, fig. 28) was made, shortly after the occurrence, which shows one worker-minor standing before the rotund with head and body erect, antennæ atent, with every mark of curious interest in her deportment. She watched the struggles and mute appeals (as it seemed to me) of her unhappy comrade, who by great exertion had suc-

ceeded in heaving up the clod, and then "passed by on the other side." Meanwhile a second worker was perched atop of the clod, coolly and cosily combing her back-hair and antennæ! This tableau is simply characteristic of the ordinary behavior of the workers.

An apparent exception was noted in the case of a semi-rotund who was overtaken in a gangway by water with which I was supplying the community, and stuck fast in a bed of mud. For a long time the workers, who were incited to masonry, as usual, by the water supply, dug and traveled around and over the imbedded ant without notice of any sort. Finally one stopped and licked the antennæ and head of the prisoner, who began to struggle, and so dropped down a little into the gangway. Meanwhile the first-comer had left. A second ant stopped, applied the tongue a moment, gave a little tug at the unfortunate, and was off. Still the stream of workers passed on. Finally, an additional pull from below was given by a concealed worker, but when I closed the observation the ant was still imbedded in the mud within the gangway. It was impossible to decide in this case whether the helpers noted were moved by personal kindness, or rather (as is most likely), by the same impulse which directs them in ordinary mason operations and toward supposed dead comrades.

Sir John Lubbock, who has made interesting experiments and observations with a view to testing the presence of benevolent feeling in ants,[1] does not have a very high opinion of emmet charity, but concludes that there are "individual differences," and that among ants, as with men, there are Priests and Levites, as well as Good Samaritans. I am much inclined to the view that anything like individual benevolence, as distinguished from tribal or communal benevolence, does not exist. The apparent special cases of beneficence, outside the instinctive actions which lie within the line of formicary routine, are so rare and so doubtful as to their cause, that (however loth), I must decide against anything like a personal benevolent character on the part of my honey-ants.

Such an example, indeed, as one of those cited by Lubbock,[2] viz., the neglect on the part of co-formicarians to remove the decapitated heads of enemies from the limbs to which they are firmly clasped, does not seem to me as remarkable as it does to

[1] Journal of the Linnæan Society, Zoology, Vol. XII, p. 497.

[2] Op. cit. p. 492.

Sir John. I have often observed the same fact among various species, and, knowing by experience, the difficulty of unloosing those formidable jaws, clasped by their immense muscles in the rigor of death, would charge it to inability rather than indisposition, that these adhering death's-heads are not removed by kindly offices of comrades. But such examples as are here recorded, together with kindred ones given by Lubbock, may fairly be quoted against the existence of a personal benevolent character in ants. However, the question can by no means be regarded as settled.

Cleansing and Feeding Larvæ.—One or two miscellaneous observations may, perhaps, be allowed a place in this connection. The solicitude of the workers for the helpless larvæ was a matter for continual admiration. The offices of nurse do not seem to be confined to any one caste, but the burden of duty appeared to be assumed by the dwarfs, and next to them the minors.

When the grub is to be cleansed it is taken in the mouth, turned by the fore pair of legs, the antennæ meanwhile touching and apparently aiding, while the mandibles are applied over the grub, their teeth apparently working chiefly within the annular divisions of the several joints. Doubtless this motion is accompanied by a free use of the tongue, but this I did not observe.

When the grubs are to be fed, the workers pass from one to another, striding over them, and standing among them (Pl. VI, fig. 34) as they lie in little groups. The wee white things perk up their brownish yellow heads, which they stretch out and move around, evidently soliciting food. Their nurses move from one to another, apply the mouth for a moment, and pass on.

At the slightest alarm the grubs are seized and hurried into the recesses of the nest. Their position is frequently changed, from higher to lower, from outer to inner rooms, and the reverse, without any purpose which I could discover or imagine. When this sort of transfer was not going on, the nurses would often be engaged in shifting the position of their charges, flitting restlessly among them, picking them up, turning them around, putting them down again, with an aimless uneasiness that bore an amusing likeness to the dandling which human infants undergo at the hands of certain young mothers.

Toilet Habits.—It has been said that the honey-bearers are cleansed by the workers. This is the rule; but the rotunds are

not wholly dependent for this upon their fellows. In one of my formicaries, the rotunds when placed within the light, began to cleanse themselves, without leaving their perch. They held on to the roof by the two hind legs and one of the middle pair, and used the other middle and the two fore legs in the usual manner of ants.[1] They were quite able thus to draw a leg through the spur-comb of one of the fore-feet; to brush the head, etc.

In one case I even saw a honey-bearer performing the offices of the toilet upon a worker. The latter held her mandibles apart, while the rotund licked the mouth parts; and from thence proceeded to the vertex of the head. Both insects were in a semi-rampant posture the meanwhile.

Fraternal Relations with Sister Colonies.—A few experiments upon several nests quite widely separated, showed that as in the case of some other ants,[2] the inmates (of the same species) fraternized completely, and engaged within the artificial nests, in the care of the larvæ, cocoons, honey-bearers, and in all other formicary duties.

IX. Economy of the Honey-Bearers.

What is the economy of the remarkable structure and habit presented in the honey-bearer? The naturalist is shut out from all observations in natural site that might give answer to this question. But from studies thus far made upon my artificial formicaries, from structure, and from reasonable analogy, I have little hesitation in saying that the economy is precisely that of the bee in storing honey within the comb. The difference lies in the fact that the bee puts her store within inorganic, the ant within organic matter; the bee within the waxen cell which her industry constructs, the ant within the living tissue of her sister formicarian, provided to her hands by the Creator. The honey is held in reserve within its globular store-room of animal tissue for times when the workers fail to gather food, or the supply fails in Nature. The queen, the virgin females, the males, the teeming nursery of white grubs, are all and always altogether dependent upon others for nurture. During the winter months and in seasons when the honey supply is scant or wholly fails,

[1] See Toilet Habits of Ants, in Agricultural Ants of Texas, Ch. VIII, p. 135.

[2] Mound-Making Ants of the Alleghenies, p. 281.

perhaps during the long rainy seasons, the entire family must have food. Precisely as the bee goes to the honey-comb in such emergencies, the honey-ant goes to the honey-bearer.

There is, to be sure, a corresponding difference in the mode of eliciting the stored sweets. The bee breaks the cell and laps the honey. The hungry ant places her mouth to that of the bearer, from whose mouth it is received as it is regurgitated from the honey crop. The muscles of the abdomen act upon that organ as does the pressure of a lady's hand upon the eau-de-cologne within the elastic bulb of a toilet jet or spraying bottle. It is forced up, gathers in a little globule, a honey-dewdrop, upon the filament-like maxillæ under the jaw, whence it is lapped off by the waiting pensioners. The admirable adaptation by which the ant's structure is fitted for this function, will be noted further on. It may be well to state such facts as appeared in various efforts to arrive at the truth of the above opinion, viz., that the honey-bearers serve as store-houses of food for the inmates of the nest. If these facts fall short of a complete demonstration, they at least form a chain of evidence which creates a very strong probability.

1. Regurgitation of Honey.—On the occasion of the discovery that the ants collected nectar from the oak-galls, a branch upon which the foragers were at work was removed to my tent for study. First, however, it was taken to the home site, and a dwarf worker coaxed upon a leaf and laid on the nest. She seemed much confused, and evidently did not at first recognize the fact that she was at home. The workers around the gall, who were quite easily distinguished by the smaller size of their abdomens, also showed marks of surprise at this unexpected arrival. However, two dwarfs and a minor soon sufficiently recovered their equanimity to arrest their fellow and "take toll" from her mouth of the syrup with which her crop was well charged. (Pl. V, fig. 24.) The mode was that which is common among ants, and has been fully described.[1] A worker major was next transferred from the bush to the nest, and showed the same confusion at this unexpected "railroading" home. She also was tolled by the ants clustering upon the mound. In both cases I saw the drop of liquid honey sparkling as it passed, a lantern having been placed on each side, thus throwing light fully upon

[1] See Mound-Making Ants, p. 275.

the group. The major, after her first confused hesitation, seemed inclined to start again on the trail, but after being tolled entered the gate. It thus appeared at the outset, that the honey collected by the foraging parties is served out to the sentinels, working parties and others at the nest, precisely as has been fully shown in the case of the mound-making ants of the Alleghenies.[1]

2. The act of receiving supplies from the honey-bearer was observed by me soon after the transfer of the ants to an artificial nest. The rotund threw her head up, raised her thorax, and regurgitated a large drop of amber liquid, which hung upon the mouth and palps. At first two ants were feeding—a major, who was in a position similar to that of the rotund, and a dwarf who stood upon her hind legs and reached up from below. During the feeding another major was attracted to the banquet, and obtained her share by reaching over the back of the first worker, indeed, partly standing upon her, and thrusting her mouth into the common "dish." (Pl. V, fig. 24.) The mandibles and maxillæ of the pensioners serve as a sort of dish, upon which a particle of honey is taken and afterward is licked off more at leisure.

3. Workers fond of the stored Honey.—The fondness of the workers for the store within the rotunds was strikingly shown during the excavation of a nest. Necessarily, in breaking down the rooms, the distended abdomens of some of the honey-bearers were ruptured. The high state of excitement which pervaded the colony, the ordinary instinct to defend the nest and preserve the larvæ, cocoons and other dependents, were at once suspended in the presence of this delicious temptation, and amid the ruins of their home the workers paused, clustered in large groups around the unfortunate comrade, and greedily lapped the sweets from the honey-moistened spot. It was a pitiful sight to see, and was noted with a mild sort of indignation, and to the disparagement of the ants, until I remembered that history has often recorded, and, indeed, I myself have seen, the humiliating fact that human beings have exhibited a like greed and ignoble self-gratification amid the perils and threatened wreck of their country and homes.

Treatment of Dead Rotunds.—Over against this fact may be placed one seemingly more to the credit of our Melligera. From time to time the honey-bearers died. The bodies of those who perished upon their perch would hang to the roof for days before

[1] Op. cit., p. 277.

the death-grip finally relaxed and they fell. It happened more than once that the workers failed to perceive the change, and for some time, a day or more, after death, continued to cleanse and tend them with the accustomed solicitude. When the fact was at last perceived, and the dead removed, the round abdomen was first severed from the thorax by clipping the petiole, then the parts were separately removed to the "cemetery," that common dumping-ground for the dead, which these ants, like all others whom I have observed, invariably maintained. In view of the fact last recorded, it seemed curious that the stored treasures of these "honey-pots" were not secured by cutting the sealing tissue. In point of fact, this was never seen to be done, and the amber globes were pulled up galleries, rolled along rooms, and bowled into the graveyard along with the juiceless legs, heads and other members. I verily believe that they were never once deliberately opened, in spite of their tempting contents. If this act were the result of an instinctive sentiment by which Nature guarantees protection to the living honey-bearer (and this, indeed, is likely), it must seem to us very beautiful and praiseworthy. But what if it were only the consequence of a mentalism so low and fixed within its instinctive ruts as to hinder even a suggestion of utilizing the wasting store by opening the abdomen?

4. Effects of Withholding Food.—In order to determine beyond doubt the relations of the honey-bearers to the other ants, I made a number of experiments, which, I regret to say, led to no decided conclusion.[1] One or two of them, however, gave results of some value. A number of rotunds and workers were placed in a nest, and denied all food. A little water was allowed them, but for more than four months their fast was not otherwise broken.

[1] An unusual press of professional and domestic duties during the winter of '79–80 absorbed even my evenings and those leisure hours which I feel at liberty to devote to natural history. I was thus unable to give to my little friends that attention which might have assured a complete success. On one occasion, just as a long series of preparations promised satisfactory results, a family bereavement intervened, and when it was possible to resume observations, the hour of advantage had passed. Then followed the untimely destruction of my captives, as will be related hereafter, and the estopment of all study. Naturalists, at least, will know how to estimate the various ordinary as well as extraordinary interruptions and hindrances with which the observer has to contend, and which often prevent the most satisfactory results.

It was my hope that this prolonged separation from external food supplies would compel the workers to resort to the honey-bearers for food, and thus afford the positive proof that the latter were the natural storehouses of the colony. Most provokingly, the perverse Melligers made the room of the honey-bearers within the very heart of the nest, and no strategy of mine could tempt more than one or two of the rotunds into a position under my eyes. I was therefore limited to such inferences as might be drawn from the general condition of the inmates during and at the close of the fast.

During the entire four months, the workers, whose movements were of course observable, were in perfect health and good condition. Indeed, it was very evident that they were in a more healthy state, more vigorous and active than the inmates of the other nests. When the nest was finally opened the remaining workers had well-filled abdomens, all of them looking more like foragers freshly returned from a banquet of nectar among the oak galls, than like the victims of a four-months' seige. The abdomens of the honey-bearers were undoubtedly diminished, but presented little appearance of having been largely drawn upon by hungry workers.

The complement of this experiment over a nest of workers who were wholly separated from honey-bearers, and denied food, came to an untimely end. The purpose had been to make such a comparison between the two sets of workers as would have shown what effect the presence of honey-bearers had upon the abdomens.

5. COVERING OBNOXIOUS MATTER.—Two other formicaries were established with the special purpose of determining whether the workers habitually transferred food to the sedentary insects upon the roof. One colony was fed syrup mixed with carmine, the expectation being that if the ants ate this and fed it to the honey-bearers, the color would show through their abdomens, or be discovered by dissection. The experiment failed, as to its main purpose, but was the occasion of uncovering an interesting trait. The carmine-syrup was obnoxious to the ants. Some tasted it, turned away, and rubbed their mouth parts upon the earth, with evident tokens of dislike. Others tested it with their antennæ, and although they had been prepared for a banquet by previous fasting, refused to eat. Moreover, they instantly, deliberately, and with one accord set to work to cover up the offensive material.

The syrup had been placed upon large corks, hollowed out atop into little dishes, and set in the soil. One cork projected an inch above the surface, and up this the workers climbed, carrying pellets of earth and gravel, from the very bottom of the nest, four inches below the surface. These pellets they dropped into the syrup, until the dish was filled and heaped up high. Some of the bits of gravel were quite large, of greater bulk, and several times heavier than the ants. As the nests were made of their native soil, I thus saw the ease with which the workers carry up the gravel stones, that cover their mounds (Pl. VI, fig, 30).

A broad trail of syrup was forced down one side of the cork, and it also was covered. This required more delicate management, as the ants were forced to support themselves upon the perpendicular surface of the cork, and, working side-wise, daub the dirt into the syrup, and fix it there! The whole trail was thus covered from top to bottom. The syrup was fed to another formicary with precisely the same results.

This was not the only occasion on which food given the ants was thus served. A crushed grape, and a juicy bit of a pear were covered in the same way in four of the nests. The fruit did not seem to be relished by the ants, yet I am not sure that the juice may not afterwards have been lapped from the soil which absorbed it. White sugar the ants took freely; bees' honey was not so much relished.

In the meanwhile, during the progress of these observations, I found that the semi-rotunds, at least were not wholly dependent for food upon the workers, as they partook freely of the sugar. But I never saw a honey-bearer, one of full rotundity, taking food or drink.[1] One might imagine that they are quite independent of outside supplies after they have once reached that state, and could spend the remainder of their lives, unless greatly prolonged, without eating. The question of chief interest here is: are they brought to that state by the deliberate action of workers in feeding them? I believe that after a certain point of distension this is the case. But the belief does not yet rest upon positive demonstration. We now proceed to the anatomy of the creature, which may afford some additional light upon this question.

[1] I substituted for carmine Prussian blue, which Dr. Forel had used for staining living ants (Fourmis de la Suisse, p. 110), but had no better success, although some of the ants fed upon the colored sweets.

X. ANATOMY OF THE ALIMENTARY CANAL IN THE HONEY-ANT.

These questions, closely related, required answer:

I. Are the honey bearers a distinct caste?

II. How is the peculiar dilated condition of the abdomen to be accounted for?

III. What is the condition of the digestive organs in the abdomen of the honey-bearer?

There are some field observations that have a bearing upon these questions:

1. The workers observed returning from foraging excursions had largely inflated abdomens. This is an ordinary experience with ants; the workers of *Formica exsectoides*, our mountain mound-builders, for example, returning from attendance upon the Aphides with their crops very much swollen. The workers of Melliger, however, seem to have an especial elasticity of the crop, which gave the abdomens of some of the returning repletes a nearly semi-rotundity.

2. These repletes and semi-rotunds in my artificial nests adopted in a measure the sedentary habits of the honey-bearers, and perched upon the roofs, where they hung quite persistently. They were often very sluggish, but more ready to move than the rotunds, and at times showed much activity, though not greatly disposed to work. (See Pl. III, fig. 6.)

3. In the formicaries opened in natural site, I observed, what Llave had seen from his specimens, that there were several degrees in the sizes of the honey-bearers in the honey-rooms.

4. There was an apparent growth in the abdomens of the sedentary workers in the artificial nests. As early as September 7th, 1879, I made this record in my note-book: "It begins to dawn upon me that the worker majors become honey-bearers. Many of them hang in the nests to the honey-rooms. In 'B' nest the entire line along the upper margin of the large room is composed of this rank." Honey-bearers with abdomens distended from one-half to two-thirds the full size were continually noted, and I could only infer that they were recruited from the number of the sedentary majors. In fact it became difficult to mark the individuals in whom the sedentary major ceased and the honey-bearer began.

5. A series of experiments was attempted to solve this point. Semi-rotunds or sedentary majors were separated, freely fed, and their growth noted. They never exceeded the condition of about

two-thirds the usual spherical abdomen. What the result would have been had they lived the entire year, and how long it would have taken them to attain the rotund condition can only be guessed.[1]

6. Among the callows, or young ants, collected, I could find no evidence at all of a separate honey-bearer caste. Among the larvæ there were some large, broad grubs, that differed much from the others, which I supposed to be queen-grubs. I was not able to hatch these and the cocoons, and observe results, a process which would probably determine the whole inquiry. The cocoons collected were all of three sizes, corresponding in length to the workers, major, minor and dwarf or *minim* as this smallest caste might perhaps be called.

7. A comparison of the workers with the honey-bearer shows that there is absolutely no difference between them except in the distended condition of the abdomen. The measurements as to length and size of head, length of legs and thorax are precisely the same. This appears to be true also, of some of the smaller rotunds and the minors.

My conclusion from the above facts is that the worker majors, for the most part, and sometimes the minors, are transformed by the gradual distention of the crop, and expansion of the abdomen, into the honey-bearers, and that the latter do not compose a distinct caste.[2] It is probable, however, that some of the majors have a special tendency to this change by reason of some peculiar structure or form of the intestine and abdominal walls.

8. Finally I undertook an anatomical comparison of the honey-bearers and workers. I made a large number of dissections, which were carefully studied and compared, and these observations

[1] Some observer upon the field might readily take up these and other experiments and carry them to a satisfactory conclusion. There are invalids at Colorado Springs and Manitou, who might follow the admirable example of the late Mr. Moggridge at Mentone, and find both enjoyment and prolonged life in some such studies.

[2] I am glad to be confirmed in this opinion by Dr. Aug. Forel, to whom I early sent specimens and notes, and who has shown a gratifying interest in these studies, and has cordially aided them by valuable suggestions. See a communication to the Morphologico-Physiological Society of Munich, in *Aerztlichen Intelligenz-Blatte*, Jan'y, 1880.

strengthened, I might almost say entirely confirmed my opinion.[1] Some of the results thus obtained will have value to many students, and they are therefore briefly presented here. Without entering fully into anatomical and histological details, enough will be given to confirm and explain the facts related and opinions stated above.

THE ALIMENTARY OR INTESTINAL CANAL.—The whole course of the alimentary tract from the mouth to the anus was carefully worked out in many dissections. Less attention was given to the head; the pharynx and mouth parts were, however, worked out. Attention was, of course, chiefly directed to the abdomen and contents.

The intestinal canal is composed of the following parts:

I. Within the head there are:

§ 1. The mouth and the mouth-parts, viz.: the mandibles (Plate VII, figs. 37, 38) *mb.*,[2] which are armed with teeth of irregular size; the maxillæ, *mx*, and maxillary palps, *mx. p*; the labium, *lb.*, and lower lip, the labial palps, *lb. p.*, and the tongue, *to.*

§ 2. The buccal sac (fig. 51, *bc.s*), a spherical expansion at the anterior part of the pharynx, in the middle of the front part of the head. Its function is not determined.[3] It is frequently found filled or partly filled with various, amorphous particles, the debris of food, etc. Brants, who first discovered it in the wasps, supposes that it may serve those insects in the preparation of their paper-nests. Forel conjectures that it may serve the purpose of a special digestion for the anterior part of the body. Lubbock once found in it an entire worm. It would appear to be a sort of anatomical "Botany bay" for the temporary seclusion of such food material as may not be prepared to yield the juices which alone pass into the crop.

[1] I mounted many of my preparations for more leisurely study under the microscope, and they have been submitted to the Academy of Natural Sciences of Philadelphia. I acknowledge here the assistance and advice of Prof. J. Gibbons Hunt, M. D., in these studies, whose unrivaled skill as a microscopist was cordially placed at my disposal.

[2] The reference-symbols are uniform in all the figures, and are for the most part such abbreviations of the names of the parts as may aid the memory in studying the plates. See the key to reference symbols.

[3] See Forel Swiss Ants, p. 109; Lubbock, Microscop. Jour., London, 1877, p. 139; Agricultural Ants of Texas, p. 119.

§ 3. The pharynx (fig. 51, *px.*) a strongly muscular wall situated within the head in front of the neck, *nk.*

II. Within the body there is the œsophagus (*œ.* fig 52), a muscular tube[1] or canal which passes through the neck and petiole, and connects the head with the abdomen.

III. The parts within the abdomen, which most concern us are

§ 1. SEGMENTAL PLATES OF ABDOMEN.—It is first necessary to understand the structure of the wall of the abdomen. This consists of ten strongly chitinous segmental plates, five dorsal and five ventral (Pl. VII, figs. 53, 54). These overlap one another, like scales, from the base toward the apex, and the dorsal plates overlap the ventral. The last plates which guard the cloacal cavity, are known as the pygidium (*py.*) and the hypopygium (*hy.*) The anus, in Melliger is surrounded by a circle of strong bristle-like hairs.

These plates, in the normal condition of the abdomen, are set upon (if I may so say) a strongly muscular inner wall, which is highly elastic in all ants, particularly of the Formicidæ. This elasticity appears to reach its extreme point in Melliger. In ordinary excessive feeding, the distension of the crop causes the expansion of the muscular coat between the plates which are thus forced apart, at various degrees of separation, according to the amount of food taken, until in the case of the honey-bearer of Melliger the three middle plates (Nos. 2, 3, 4) are wholly isolated, appearing, as Forel has well said, like little islands on the tersely stretched, light colored abdominal membrane. (Plate VII, fig. 54, D2, 3, V2, 3), (Plate X, figs. 72, 73). Plates D1, V1, retain their normal position, and plates D4, V4, are not so widely separated from D5, V5, as from their next anterior plates.

We may now view the abdominal portion of the intestinal tract, in order to understand what happens in the growth of the honey-bearer.

§ 2. THE CROP OR INGLUVIES.—The crop is the anterior and superior sub-division of the abdominal portion of the alimentary canal. It is simply an expansion of the œsophagus within the abdomen. The normal condition of the crop was determined by examination of the workers with undistended abdomens, and more readily from the study of a virgin queen (Pl. VIII, fig. 59).

[1]Forel, quoting Meinert, speaks of the muscularization as feeble; but in Melliger, at least, the muscles appear to be sufficiently strong.

The œsphagus *œ*, is there seen passing through and bent over the hard ring (*Jn*) which forms the junction of the petiole and abdomen. The œsophagus is seen as continued (*œ c*) within the abdomen, where it has precisely the same structure as within the thorax. The crop or ingluvies contains a moderate amount of food and is fairly distended. The exterior coat of the crop is a net-work of muscles which present the branched character sometimes found in insects (Pl. VII, fig. 45). Another section of the crop showing the character of this muscularization is given at Fig. 46. This enlarged view is taken from the object shown at Pl. VIII, fig. 55, and is made at the margin. The spherical crop is thus seen to be hung within the muscular netting, something like an inflated balloon within its net bag.

Forel thinks[1] that the muscles of the segmental walls of the abdomen alone are concerned in the act of regurgitation; but I see no ground for this opinion, except possibly with the honey-bearers, whose abdominal muscles alone might suffice to expel the contents of the crop. Such a remarkably efficient structure as is here demonstrated and illustrated, can hardly be without its proper function.

Before proceeding to demonstrate the main point in hand, it will be well to follow the alimentary canal to its termination.

§ 3. The Gizzard or Proventriculus.—The crop is continued posteriorly by the gizzard, *gz* (Pl. VIII, figs. 55, 56, 57, 59), a singular and complicated organ in ants which has given rise to conjectures the most diverse. Meinert regards it as serving to regulate the movement of the aliments. Forel thinks it certain that it serves above all to close, and for the most part hermetically, the digestive canal between the crop and the stomach.[2] The gizzard properly belongs to the anterior part of the intestinal canal its internal cuticle (*tunica intima*) being a direct continuation of the crop, œsophagus, pharynx and mouth. It consists in Myrmecocystus (and the entire sub-family Camponotidæ) of three parts.

[1] Swiss Ants, p. 111.

[2] The gizzard varies largely among ants, and the variations form generic characters of great value, which Dr. Forel has shown, first in his "Fourmis de la Suisse," p. 112, seq., and afterward, more fully and clearly, in his "Études Myrmécologiques," *Bulletin de la Soc. Vaudois d. Sci. Nat.*, Vol. XV, 1878, pp. 337, 392. This last study of this organ is one of the most admirable contributions yet made to myrmecological histology.

1. The anterior part, or gizzard proper, a lily-shaped organ composed of a spherical bowl (*b.gz*) and four blades or sepals, *s.gz*. It is strongly chitinous, appears intact in all dissections, and is easily seen. The crop contracts at the posterior end within the four sepals of the gizzard, which thus appear to act as valves to regulate or moderate the flow of aliment from the crop to the stomach. What, if any, action it may have upon the food is not known; it can hardly have the usual function of trituration, as ants do not receive solid food into the crop.[1]

2. The middle part of the gizzard, or cylinder, *cy.gz*, is a straight cylinder, with a fine, transparent internal cuticle whose matrix is surrounded by a compact coat of transverse striated muscles. Exteriorly the cylinder appears to merge directly into the stomach. Only the muscular coat, however, is thus directly continued and expanded into the fine muscular bag-net of the stomach (Pl. VIII, fig. 57).

3. The internal cuticle of the gizzard traverses the walls of the stomach accompanied by its matrix, and projects within the cavity of the stomach, terminating in an elongated bulb, which is the button, *bn.gz*. (fig. 57), *bn*. (fig. 59), or posterior part of the gizzard. The anterior and posterior parts of the gizzard are always found in ants, the first varying greatly, the latter scarcely at all. The cylinder, on the contrary, is wholly wanting in many genera, and in others undergoes great variations of length. The entire organ is united to the crop externally by a strong muscular netting, so that the two might be compared to a balloon (crop) and the car (gizzard) and the enfolding muscles to the network swinging between the two.

§ 4. The Stomach.—The stomach, *stm* (Pl. VIII, figs. 55, 56), like the gizzard is always easily discernible, inasmuch as a quantity of solid amorphous matter within it, of a dark brown or blackish color, betrays its presence even through the segmental plates. It is commonly spherical or ovate in shape.

§ 5. Malpighian Tubes.—Around the posterior pole of the stomach are grouped the Malpighian vessels, *mpg* (figs. 56, 60), twelve in number.

[1] The various sections of the bowl appeared to me to have upon their interior edges certain tooth-like inequalities, which suggested at least the office of triturating or *agitating* the passing food. These may be, however, nothing more than longitudinal flutings upon the external surface.

§ 6. THE INTESTINE.—The location and appearance of the intestine, is seen in fig. 56, more clearly in fig. 60. The ileum (*il*) passes from the posterior pole of the abdomen, and appears to be united to the colon (*col*) by a fold which I have ventured to refer to as the ileo-secal valve (*il.v*). The rectal glands (*re.gl*) appear upon the colon, and the rectum (*re*), a strongly chitinous and muscular structure, terminates in the ciliated anus (*an*).

Finally, Pl. VIII, fig. 58 [1] will show the relative positions of all the organs opening into the cloaca. See Explanation of Plates, fig. 58.

We may now construct for further illustration the synthetic figure, Pl. IX, fig. 61, giving a side view of the entire intestinal canal *in situ*. This will indicate the normal position of the crop relative to the abdomen and the other alimentary organs. It will be seen that it occupies a position anterior and superior to these. The natural tendency of the pressure caused by the expansion of the crop, as it fills the abdominal cavity, would be to force the remainder of the tract backward and downward. In point of fact it is so found. A number of workers, with abdomens in various degrees of distension were examined, and the condition and site of the digestive organs noted. A few outlines of these abdomens are given:

The series begins with Fig. 63 (Pl. IX), where the crop is shown in nearly normal site, and well filled.

The same condition is indicated at Fig. 66, except that the crop shows marks of having once been quite distended and afterward emptied.

Fig. 64 shows a worker, whose crop about half fills the abdomen. The gizzard, *gz*, is forced downward (ventral) and has the anterior poles of the sepals turned upward (dorsad). The effect of subsequent pressure (should the crop have expanded), in forcing the stomach, etc., backward and downward into the cloacal cavity, can readily be predicted from the figure.

In Figs. 62 and 65, the abdomens of workers in the semi-rotund state, the distension has advanced a little further so as to push the stomach in one case (62) as far as, in the other (65) partly beyond, the fourth segmental plates, compressing the intestine proportionately.

[1] Adapted from Forel, "Der Giftapparat und die Analdrüsen der Ameisen," *Zeitschrift f. wiss. Zool., Bd. XXX.*

That the same results follow in all the worker castes may be seen in Fig. 67, the abdomen of a minim or dwarf worker.

Turning to the honey-bearers, we find precisely the same condition of the abdomen, except that the distention of the crop has greatly increased, pushing its walls in all directions quite up against the inner walls of the abdomen, forcing the latter into rotundity, and compressing the other organs into the smaller space.

Fig. 69 is the abdomen of a honey-bearer, which appeared to be a little short of the full rotundity. The crop filled the entire cavity, but the gizzard, stomach and intestine, instead of being crowded together upon each other, were in their normal relations, and appeared to be in an entirely healthy state. The aspect of many of the bearers raised the query, whether the anus might not be sealed by the organs forced against it, thus stopping all excretion, and making the animal simply a vital honey-pot. The above individual, at least, had every appearance of normal condition and action of all the organs.

In the next example (fig. 70), the gizzard, stomach, malpighian vessels and intestine are forced down quite within the compass of the fourth pairs of segmental plates, and directly over the cloacal vent. For the most part these organs are situated ventral, but here they are partly dorsal of this cleft. The most usual position of the stomach in the honey-bearers is between and quite close to the fifth and fourth ventral plates. The gizzard is a little anterior of this, the sepals, which mark the posterior pole, or entrance of the crop within the gizzard, being directed downward, upward, downward and backward, upward and backward, or forward, at hap-hazard.

Another illustration is given (fig. 68), in which the crop of a honey-bearer is seen in the act of contraction, after having been punctured through a slit (*s*) in the abdomen. When one holds a rotund up to the light, and looks into the semi-transparent abdomen, it is not possible to distinguish the crop from the abdominal membrane. But in the example here figured, as the honey flowed out from the pierced crop, the slowly contracting and thickening folds of the partly emptied organ were thus revealed. Nothing could demonstrate more clearly than this experiment and figure, that it is *the crop alone* which fills the distended abdomen.

I venture to add a final illustration to this series. I was en-

abled to separate a crop *entire* from the abdomen, and mount it for microscopic examination. In this delicate work, which could not otherwise have been done, I was aided by some morbid condition of the abdomen. I occasionally noticed, both in the natural and artificial nests, honey-bearers whose abdomens had the appearance of cones (Pl. VI, fig. 33) and the outer membrane hung in folds.[1] They seemed to have suffered some injury, which apparently had affected the crop. It was from one of these that the crop (Pl. VIII, fig. 55) was taken.

These studies point to the following conclusions:

I. *First*, and absolutely, that it is the *crop alone* which contains the nectar received at the mouth, which, immensely distended thereby, fills the rounded abdomen of the honey-bearer.

II. *Second*, and absolutely, the organs of the abdominal portion of the alimentary canal in the honey-brearers are ordinarily in a natural state, except in so far as their position has been changed by the downward and backward pressure of the expanding crop. This condition of the abdomen is frequent, in a greater or less degree, among ants.

There has been much error and loose statement on this point among authors. So eminent an anatomist as Dr. Joseph Leidy supposed that the honey was contained within the stomach; that all the other viscera of the stomach were obliterated, and that even the tracheal vessels had entirely disappeared.[2] Dr. Oscar Loew[3] makes some correct notices of the honey-ant, as seen at Santa Fè, New Mexico, but permits himself to recognize "the intestine . . as a narrow canal winding through the rounded and puffed up abdomen." This could only, in any sense, be affirmed of a small part of the abdomen, the posterior portion into which, as we have seen, the intestine is crowded. It is possible that the dorsal ves-

[1] I do not credit the statement (Loew) that many of the rotunds burst by force of the pressure upon the crop. Probably this never occurs in nature. The spots of moistened clay seen by observers rather mark the wreck of ants crushed by pressure upon the chambers and galleries during excavation, or ruptured by falling from the roosts.

[2] Proceedings Academy Natural Science, Vol. VI, 1852, p. 72. This, however, was twenty-nine years ago.

[3] Chemist and mineralogist to Lieut. Wheeler's Exploring Expedition, *American Naturalist*, Vol. VIII, 1874, p. 365-6.

sel may have been mistaken for the intestine, as this may be seen in some specimens very plainly.

Dr. James Blake[1] has published a brief report in which he falls upon an error quite the reverse of Dr Loew.[2] "The intestine of the insect," he says, "is not continued beyond the thorax, so that there is no way in which the remains of the food can be expelled from the body, except by the mouth." It follows, of course, that with this view, he should further err in supposing the honey-bag to be formed simply by the expansion of the abdominal segments.

The illustrations above figured, on the contrary, show that the intestinal canal has neither been ruptured, nor resorbed, nor otherwise disposed of than is quite natural.[3]

III. *Third*, it is seen that the process by which the rotundity of the honey-bearers has probably been produced, has its exact counterpart in the ordinary distension of the crop in over-fed ants; that, at least, the condition of the alimentary canal, in all the castes is the same, differing only in degree, and therefore, the probability is very great that *the honey-bearer is simply a worker with an overgrown abdomen.*

If this last conclusion has not been fully demonstrated, it has at least been shown that there is no anatomical or physiological obstacle thereto, but very much confirmatory thereof.

THE AUSTRALIAN HONEY-ANT.—An exceedingly interesting discovery of a new species of honey-ant, adds to the probability of this last conclusion. Sir John Lubbock has described this species as *Camponotus inflatus*,[4] from specimens collected at Adelaide, Australia. I received examples through the courtesy of Mr. Gerald Waller, last summer, which enabled me even in advance of Lubbock's admirable description, to note that a con-

[1] Proceedings California Academy Science, 1873, part II, page 98.

[2] Dr. Forel, in the communication to the Morphologico physiological Society of Munich, already alluded to, appears to me to have misunderstood Dr. Loew's *published* statement. Dr. L. erred in seeing *too much* intestine, instead of none at all.

[3] It is not worth while to more than mention here the opinion which has been largely circulated, that the workers *bite and wound* the ends of the abdomens, producing thereby an inflammation which seals up the anus, stops all excretion, and so causes the repletion of the abdomen.

[4] Journal Linn. Soc. Zoology, 1880, Vol. XV, p. 185, seq.

dition supposed to be peculiar to our American Melliger, obtained in an Australian species belonging to a genus quite removed from *Myrmecocystus*. Mr. Waller could tell me nothing of the habits or habitat of *C. inflatus*, and Lubbock has no account of any. But the congeners of the Australian insect are "Carpenter ants," quite generally making their formicaries in the roots and trunks of trees, and thus in economy as well as structure differ from *M. hortus-deorum*. This widening of the range within which this hitherto phenomenonal condition of the abdomen is found, not only raises the suggestion which Sir John makes of an independent origin of the modification in the two species, but also adds to the probability that the modification may have originated in the natural mode which I have described.

It is to be regretted that Lubbock did not make an examination of the alimentary canal of his species, which, with the material and resources at his command, would doubtless have been highly satisfactory. However, I undertook from my limited material, to make at least so much of a study of the digestive organs as would permit some comparison with results obtained from Hortus-deorum. I had but one perfect specimen, which is figured Plate X, fig. 74. The abdomen of this example was removed and carefully mounted without rupturing the abdominal walls. The result is shown at Plate IX, fig. 71, and as will at once be seen, corresponds with those obtained fully from Hortus-deorum, and as far as pursued, from Mexicanus also. The crop (fig. 71) fills the cavity of the abdomen, and the rest of the digestive organs are seen crowded into the anal region. The gizzard has the general features of that of Hortus-deorum, but has marked characteristics, quite identical with those of the genus *Camponotus* as pointed out by Forel.[1] The sepals are not deflected at the anterior pole, as in the lily-shaped sepals of Hortus-deorum, but are clavate and straight.

This fact certainly strengthens the conclusion arrived at concerning the American species of honey-bearer, viz., that the rotund has been developed by natural habit from the ordinary worker, and that the possibilities of such a condition exist in the structure and functions of all nectar-feeding ants. Why the extraordinarily distended crop seen in the honey-ant should be limited to two

[1] Etudes Myrmecologiques, Bull. Soc. Vaud. de Sci. Nat. 1878. Pl XXIII, fig. 1.

species (so far as known), and why so limited a number of workers in the formicaries of these two species should develop the round abdomen, are questions that provoke sufficient wonder, but yield scant satisfaction.

XI. Possible Organs of Stridulation in Ants.

The segmental plates of the abdomen are composed of numerous hexagonal epithelial scales, Pl. VII, fig. 48, which present a very beautiful appearance, as of delicate mosaics, when viewed through a microscope. When a profile view of one of these plates is exposed to the lens, as at fig. 49, the scales are seen to be imbricated, that is, to overlap each other like tiles on a house roof, and show the serrate edge figured in the cuts, figs. 49 and 50. The former (49) is drawn from a section of *Camponotus inflatus*, and the latter (50) from *Hortus-deorum*. This serrate edge not only shows upon the external part of the plate *e. ab. pl.*, but upon the imbricated portion, *i. ab. pl.* By referring to the manner in which the one part overlaps the other shown at figs. 53, 54, it may be seen that a backward and forward motion of the plates upon each other might produce a faint rasping sound. That this motion is entirely possible can hardly be doubted. The abdominal plates are continually, though gradually, sliding out and in, like the parts of a telescope, under the expansion and contraction of the crop, as the ant feeds or regurgitates the contained nectar. All that is required to have the complete conditions for stridulation seems, therefore, to be the muscular ability to perform this action rapidly; which, it appears to me, ants certainly possess.

I have often noticed the peculiar *hiss-z-z-z!* which arises from an excited colony or column of ants, a sound which grows in intensity according to the degree of excitement. I have also met an opinion prevalent among ordinary observers, that the ants produce this sound by some organ analogous to some one of those by which other insects produce musical notes or noises—in short (to use the popular phrase), that "ants sing." But I have heretofore been disposed to consider the noise referred to simply as the result of friction of a great multitude of insects moving rapidly over the surface of the earth, the litter of leaves, twigs, etc., and against the hard, shell-like bodies of their fellows, or possibly (also) by the gratings of the hard tooth-like mandibles upon each other.

I am not yet prepared to abandon this opinion, nor to affirm that ants do produce audible sounds by proper stridulating organs; but simply record the structural possibility of such behavior.

Since making the above note, Mr. Swinton's work on "Insect Variety"[1] has reached me. The author records an example of what seemed to be an act of stridulation by a small yellow ant, *Myrmica ruginodis*.

This insect was observed stationed near the edge of an inverted wine glass, underneath which it had been confined, its head downward, rapidly vibrating its abdomen vertically from the pedicle, and simultaneously giving out a continuous singing sound, in color and intensity resembling the sharp whining of the little dipteron *Syrilla pipens*.

Concluding that the rhythmical motion accompanying the music indicated this ant as a stridulator, the author undertook a microscopic study of its anatomy, from which the following facts appear:[2] The ant belongs to the family MYRMICIDÆ, which are distinguished from the FORMICIDÆ, to which our honey ant belongs, by having two knots or nodes to the petiole. The second or posterior knot is commonly the larger, and is placed quite near to the anterior pole of the abdomen. Upon the insertion of the abdomen into this node, were observed twelve minute yet regular annular striæ. (Pl. X, fig. 81.) This striation was produced, but less distinctly, upon the articulation of this (the second) node with the first (anterior) node. It was conjectured that the rapid movement of these joints of the petiole, back and forward upon each other and upon the abdomen (like the jointed tubes of a telescope), produced the sound above described. As the nodes are to be regarded as abbreviated segments of the abdomen, and as the abdominal segments have already been shown to be capable of movement one upon another, Mr. Swinton's interesting observation gives new value to the suggestion above made concerning the structural possibility of stridulation in the honey ant and others of like organism.

[1] "Insect Variety, its Propagation and Distribution," by A. H. Swinton, member of the Entomological Society of London, p. 106, and Pl. VI, fig. 7.

[2] The writer's account is somewhat confused by false punctuation, and he falls into the error of conjecturing that the small worker may have been a male. I have given my understanding of the structure as derived chiefly from the figure, which I reproduce with some alteration.

XII. Destruction of the Ants by Mites.

The untimely end of my artificial colonies is worthy of a passing note. The ants were brought from Colorado in large jars, domiciled in their native soil. Every precaution which circumstances would allow was taken to preserve their health, but after a confinement of over seven months, during which many of the observations noted above were made, they became infested with mites. These parasites, or their germs, were probably brought from Colorado with the insects, although I did not observe them until late in their imprisoment. However, I have seen the same or similar parasites upon other ants while in their home-nest, and more than once have suffered the loss of colonized formicaries from their inroads.

In the case of the honey ants I was powerless to give relief of any kind, and witnessed with real grief the helpless little sufferers in their struggles to free themselves from their destroyers. I have figured the head of an ant thus infested, at Pl. VII, fig. 39, where the mites may be seen clinging to the cheek, mandibles and antennæ. I have spared the feelings of my readers so far as to figure but a few of the pests. In point of fact they literally covered the mouth parts, where they were chiefly congregated, although they were attached to other parts of the body. The poor "host," although so admirably provided with implements for cleansing her person—such as the mandibles, mouth and tarsal comb—found all efforts to rid herself of her "guests" futile. Even that friendly aid in toilet service which one emmet is wont to extend to another, was vain. Gradually the poor victim yielded life to the parasitic swarm that sucked at her vital juices. The charnel-house—the little cemetery centre at one side of the formicary—gained many inmates daily; the galleries and chambers thinned of their busy populace and grew lonely; at last, as in some plague-stricken human commonwealth, the dead were suffered to lie where they fell, for the living were themselves sealed to death, and unable to give their comrades sepulture. So my nests faded away, until, unwilling longer to witness their sufferings, I gave them all a painless death.

My studies were seriously interfered with by this calamity, as many of my well-nigh ripened experiments thus came to nought. But one cannot complain, for Nature and Destiny pursue ants

also, and that this particular form of insect doom is unhappily not rare has long ago been voiced in the familiar couplet:—

> "Great fleas have little fleas, they smaller fleas to bite 'em;
> Smaller fleas have lesser fleas, and so *ad infinitum*."

One might pass to the opposite pole of the zoological series—Man—and add the reflection of Quintus Serenus upon the death of the Dictator Sylla:—

> "Great Sylla, too, the fatal scourge hath known,
> Slain by a host far mightier than his own."

It might be supposed, at least I had so thought, that the presence of these parasites would greatly irritate the ants, and produce an excited behavior, and animated struggles to be rid of their guests. On the contrary, they endured the affliction with wonderful patience. It seemed to me, although one must allow in such cases for the anthropomorphic color upon his observations, that the unfortunate creatures were quite conscious of their doom, of the hopelessness of contending against it, and had yielded themselves in a philosophic resignation.

The mites are, in color, white, almost transparent, and are about one millimetre in length. I am not certain as to the species, but present correct drawings of the animals, from which they may be determined by a competent authority. (See Pl. VII, figs. 40, 41). Greatly magnified views, in several degrees of expansion, of the sucking organs, by which the mites cling to their host, are shown at figs. 42, 43, 44.

XIII. Previous Accounts of the Honey-Ant.

The first account of the Honey-ant was given to the world by Dr. Pablo de Llave, in the year A. D. 1832, in a Mexican journal.[1] A translation into French of the substance of this paper was given by Monsieur H. Lucas in the French Review and Magazine of Zoology, June, 1860.[2] Meanwhile (1838), M. Wesmael had published a description of the ant, with figures, without knowledge of the above paper of Llave, establishing for it the Genus Myrmecocystus. Wesmael's generic name remains, but his specific name

[1] Registro trimestre o collecion de Memorias de Historia literatura ciencias y Artes, 1832.

[2] Revue et Magazin de Zoologie, Tome XII, 1860, p. 271.

(*Mexicanus*) has of course yielded to that of Llave, modified, however, from *Melligera* to *Melliger*. The Colorado insects, upon which the studies of this paper are based, I have ventured to regard as a new variety, and have named *Myrmecocystus hortus-deorum*, and thus have retained Wesmael's name as a variety name.

It will be well to state briefly the facts in the economy of these insects indicated in the foregoing and other papers, in order to mark precisely the new facts which have now been communicated here.

Llave's information was all at second hand, he having made no personal observations of the habits of Melliger. From a person living at Dolores, a village in the vicinity of the city of Mexico, he learned:

1. That the ants were popularly known under the name of *Busileras;*

2. That they do not erect heaps of earth at the entrance to their nests;

3. That on opening the nest, a species of gallery is reached, to the roof of which certain ants are suspended, packed one against the other;

4. That these ants cover the roof as well as the wall of the gallery.

5. The women and children of the valley know these nests perfectly well, and frequently open them for the sake of the honey-bearers, or rotunds. The honey is sucked from the abdomen of the rotunds, with great relish, at the nests; or, if it is wished to preserve them, they are lifted by the head and thorax and placed upon plates, in which they grace the village feasts, and are eaten as delicacies.

6. The rotunds when thus placed together, stir around, lay hold of and tear one another, and finally end life by bursting.

7. The skin of the abdomen, which binds the segments together, is so thin, and the upper coat so distended, on account of the quantity of honey which it encloses, that the least pressure suffices to cause the ants to disgorge.

8. When they do not so disgorge, that is, by elevating the head and thorax, the honey diminishes, and the ants eat it.

9. Dr. Llave observed, moreover, from specimens of the ants sent to him, that there were different castes of workers and degrees of distension in the abdomens, and

10. That the honey in the rotunds varied in color from a crystal whiteness to a wine-color.

Several of the above statements, as has been seen, are without foundation, but the majority of them are confirmed in whole or part by my observations.

Wesmael,[1] who made his study from specimens sent him from Mexico by the Belgian Envoy, Baron Normann, records his credence of the theory announced by that gentleman, viz., that the honey-bearer elaborates the honey and deposits it in certain reservoirs, analogous to the cells of bees, for the nurture of the formicary. Baron Normann was unable to obtain examples of these reservoirs to send to Europe, or rather failed to do so under the conviction that they would be destroyed during shipment. In point of fact, such reservoirs exist only in imagination.

One of the most perplexing accounts of the honey-ant is that of Mr. Henry Edwards.[2] The statements recorded are made at second hand from the verbal narrative of a Capt. W. B. Fleeson, whose observations were made at or near Santa Fè. They are so extraordinary and contradictory of my own experiences, that I am compelled to withhold credence, until some experienced observer shall have corroborated them, a result of which I have little expectation. According to this account, no exterior moundlet surmounts the formicary, but simply two openings into the earth. Within the nest, at a depth of about three feet, "a small excavation is reached, across which is spread, in the form of a spider's web, a network of squares spread by the insects, the squares being about one-quarter inch across, and the ends of the web[3] fastened firmly to the earth at the sides of the hollowed space which forms the bottom of the excavation. In each one of the squares, supported by the web, sits one of the honey-making workers, apparently in the condition of a prisoner, as it does not appear that these creatures ever quit the nest."

But the marvels of this strange story are not exhausted. "The

[1] Bulletin de l' Acad. Roy. des Sci. et Belles lettre de Bruxelles, Tome V p. 770. Pl. XIX, figs. 1-4.

[2] Proceed. California Acad. of Sciences, Vol. V. 1873, p. 72; "Notes on the Honey-making Ants of Texas and New Mexico."

[3] Of course, this is pure fiction, as no ant makes a web, or anything that could well suggest one. The cutting ant does make out of fragments of leaves a "comb" of more or less regular cells, resembling the nests of the paper-making wasps.

inmates of the formicary are composed of two distinct species, apparently even of different genera, of ants. There are the ordinary yellow workers and honey-bearers of Melliger, and besides, black workers, who act as guards and purveyors. One column of the blacks surrounds the openings on three sides, attacking, driving off or destroying all intruding insects. Another column bears, through the unguarded side of the hollow square, fragments of flowers, aromatic leaves and pollen, which (adds our author), by a process analogous to that of the bee, the honey-makers convert into honey."

One can hardly refrain from the thought that Capt. Fleeson was testing the credulity of the writer by one of those jokes of which naturalists are occasionally the victims. But, if the narrative is to be taken in good faith, I can only explain the facts by supposing, first, that the observer happened upon a nest of cutting-ants (*Atta fervens*), within whose boundaries a nest of Melliger had chanced to be established, and had confounded the habits of the two as those of one formicary; or, second, that the cutting-ant, or some other species of similar economy, has really acquired the habit of kidnapping and domesticating the honey-ant for the sake of its treasured sweets, precisely as many ants domesticate aphides; or, as the slave-making ants, *Formica sanguinea* and *Polyergus lucidus*, domesticate *Formica fusca* and *F. Schauffussi*.[1]

One of the latest accounts of the honey-ant, and so far as it goes, one of the best, is that of Mr. Saunders, the editor of the *Canadian Entomologist*,[2] who communicates to his journal some observations made by Mr. Kummeck, at Santa Fè.[3] According to this observer, considerable numbers of these insects are found in the mountains of that vicinity. He sat by a nest six or seven

[1] One may not be over rash in refusing belief even to facts that go counter to all past experiences, for the marvels of Nature are ever widening within our view. While, therefore, I am inclined to reject the whole story, I await the observation of some trained naturalist, giving the account the benefit of the above possible explanations.

[2] Can. Entom., 1875, Vol. VII, pp. 12–13.

[3] I may be permitted to explain why I did not go to New Mexico, to attempt on the spot a solution of some of the questions raised by these accounts. I had made every arrangement to do so, after my studies in the Garden-of-the-gods were completed, but on the morning that I was to break camp, was taken with a sudden and violent illness which compelled me to abandon my journey.

hours and noticed the workers carry home leaves of different plants to feed, as he supposed, "the others that produce the honey." This would seem to confirm the leaf-bearing habit quoted by Mr. Edwards from Capt. Fleeson. The inference as to the use of these leaves is, however, quite unwarranted, as the portage of leaves, etc., into nests is not an uncommon habit among ants of divers species. Without stopping to discuss the question whether such material may contribute to the food supply of the formicary, it may be remarked that its most probable and ordinary use is for purposes of architecture or nest-building.

Mr. Kummeck also makes the remark, which I had not seen at the time my own conclusions had been reached, that "in early life none of these insects present any unusual distension of the body, but when arrived at a certain period of maturity some individuals begin to show a distended abdomen."

The ant honey has no commercial value among the New Mexicans. It has a place, however, as a remedy in the domestic therapeutics of the native Indians, who compound a drink by mixing three to four drachms of the honey with six ounces of water. The drink is used in cases of fever. The honey is also applied as an unguent in eye diseases, especially cataract.

To the above may properly be added two accounts of my own studies published in the London *Journal of Science*.[1] These are reports made by Mr. Morris, of the verbal communications in which my observations were originally announced to the Academy of Natural Sciences of Philadelphia. They were made and printed without any oversight or responsibility on my part, but are admirably, and in the main, accurately done. They have been reproduced with various degrees of fulness in other journals.

Such other notices of this ant as I have been able to find, and have had occasion to use, will be found properly referred to in the text of this paper, where those who are interested in the literature can readily find them.

[1] Jour. Sci., February, 1880, "Living Honey Comb; a novel phase of Ant Life." By Mr. C. Morris. Ibid. July, 1880, "Habits and Anatomy of the Honey-bearing Ant." By Charles Morris.

XIV. Description of Species.

FORMICARIÆ.

Family **FORMICIDÆ.**

Subfamily CAMPONOTIDÆ (Forel).

Genus **MYRMECOCYSTUS**, Wesmael.

Cataglyphis, Fœrster, Verh. d. Nat. Ver. d. Rheinl., 1850; Mayr, Europ. Formic., 1861; Norton, Wheeler's Report, Vol. V, Zool., p. 734.
Monocumbus, Mayr, Verh. d. Zool.-bot. Ver. in Wien, 1855.
Myrmecocystus, Forel, Etudes Myrmecologiques, Bull. Soc. Vaud. de Sci. Nat.

M. melliger, Llave.

1. Var. *mexicanus*, Wesm.
2. Var. *hortus-deorum*, McCook.

Workers.—Three castes, major, minor and minim or dwarf. Color, a uniform light yellow; the body is covered quite thickly. the legs more thickly, with short yellow hairs. The maxillary palps are very long, six-jointed, third joint longest; they are covered, especially beneath, with long hairs, curved backward. Labial palps four joints; mandibles with nine teeth. The head is quadrate, in the worker-major more rounded at the sides than with the minor and dwarf; wider than the thorax. Clypeus smooth, rounded, slightly flattened in front of the frontal area. Frontal area smooth, shining, triangular, somewhat truncated posteriorly. Ocelli sufficiently prominent; a tuft of hairs on the face beneath, directed forward. The body is of good length. narrow and compressed beneath at the mesothorax; metanotum as high as, or slightly higher than the pronotum. The node cordate, cleft at the tip, thickened at the base, set perpendicularly upon the petiole. Anus strongly ciliated. Length, worker-major, $8\frac{1}{2}$ mm.; worker-minor, 7 mm.; worker-minim, $5\frac{1}{2}$ mm.

Honey-bearers —A sedentary class or caste distinguished by abdomens distended into spherical form by expansion of the crop filled with grape-sugar. The length (including abdomen) is 13 mm. (one-half inch); the proportions and description of the head and body are those of the worker-major, of which it may be a developed form.

Female.—Virgin queen, total length, 13 mm., as follows: Mandibles, 1 m.; head, 2 mm.; body, 5 mm.; abdomen, 5 mm. Width

of abdomen, 3 mm.; of prothorax, 2 mm. Color, livid yellow. Fore-wing, 14 mm. long; venation as in Pl. X, fig. 77.

Male.—Length, 5 mm.; length of fore-wing, $5\frac{1}{2}$ mm. Color, livid yellow; the head, upper part of thorax and dorsum of abdomen blackish. The mandible has one feeble tooth at the tip, and two others shorter and feebler.

Habitat.—Southern Colorado, occupying subterranean formicaries with small gravel-covered exterior moundlet, pierced by one central gallery.

ALPHABETICAL KEY TO REFERENCES IN THE PLATES.

The references are uniform in application throughout all the figures. References which occur only once, and are explained in the "Explanation of Plates," are not placed in the Key.

ab., abdomen.
ab. pl, abdominal plate.
ab. pl. d, abdominal plate dorsal.
ab. pl. v, abdominal plate ventral.
an, anus.
an. sp, scape of antenna.
ant, antennæ.

bc. s, buccal or mouth sac.
b. gz, bowl of gizzard.
bn. gz, button of gizzard.
b. ms, branched muscles.

CL, Clypeus.
C. ms, crop muscles.
Col, colon.
Cy. gz, cylinder of gizzard.

D, dorsal.

E, epithelium.
E. i. s, epithelium imbricated, serrate edge.
E. ab. pl, exterior abdominal plate.
Epc, epicranium.

f. ar, frontal area.
fem, femora.
flg, flagellum of antenna.
fm, foramen.

gz, gizzard.

hy, hypopygium.

i. ab. pl, interior abdominal plate.
il, ileum.
il. v, ileo-secal valve.
in, intestine.

lb, labium.
lb. p, labial palps.
lbm, labrum.

mb, mandibles.
mo, mouth.

mpg, malpighian tubes.
ms, muscles.
m. th, mesothorax.
met. th, metathorax.
m. tr, metatarsus.
mx, maxilla.
mx. p, maxillary palpi.

nd, node of petiole.
nk, neck.

oc p, occiput.
oc, ocelli.
Œ, œsophagus.

p. ms, pharyngeal muscle.
pr. th, prothorax.
py, pygidium.
px, pharynx

re, rectum.
re. gl, rectal glands.

s. gz, sepals of gizzard.
stm, stomach.
str, striæ.
su, sucker.

tib, tibia.
to, tongue.
tr, tarsus.

V, ventral.

EXPLANATION OF PLATES.[1]

Plate I.

Fig. 2. View of my camp in the Garden of the gods, showing the site of some of the nests of the honey ants studied. The view is taken from the rocks at the junction of Adams and Von Hagen ridges (see Fig. 1, p. 19), and looks towards the south, and the eastern face of Pike's Peak. One of the nests is shown in the foreground, and the sites of others are indicated by the white circles on the tops of the ridges. My tent and booth are seen near the centre of the sketch, and just opposite, on the right, is the oak copse in which the ants were discovered feeding on the exudations of galls. Page 19.

Plate II.

Fig. 3. Elevated gravel cone of a honey-ant nest; the gravel is of red sandstone, and the rocks around are bits of quartz of several colors, giving a pretty effect. This nest is the largest seen, and measures three and one-half inches high and thirty-two inches around the base. Page 21

[1] Mr. Joseph Jeanes, a member of the Academy of Natural Sciences of Philadelphia, contributed the money required for the illustration of this paper, and thus has greatly added to whatever value it may possess.

Fig. 4. A nest built partly around a tuft of gramma grass, and less conical in shape than the above.

Plate III.

Fig. 5. View of honey-bearers as seen in natural site, clinging to the roof of a honey-room. About natural size. Page 22.

Fig. 6. View of honey-bearers in same position, drawn from one of my artificial nests. Mingled with them are seen ordinary workers, and semi-rotunds, or workers apparently in process of transformation into honey-bearers. About natural size.

Plate IV.

Fig. 7. Sprig of dwarf oak, *Quercus undulata*, with galls of *Cynips quercus-mellaria*, showing the beads of sweet sap. Page 25.

Fig. 8. The same galls enlarged.

Fig. 9. Another cluster of the same galls.

Fig. 10. Section of gall showing the inside cell, *c*, and the exit hole of the gall-fly, *eh*. Page 26.

Fig. 11. Turk's-head gall, showing exit hole, *eh*.

Fig. 12. View of inside of a gall, showing a globular cell, and a small grub domiciled against it. Page 27.

Fig. 13. A honey-bearer clinging by her feet to the wall of a honey-room. Page 22.

Fig. 14. The crater of a gate to an ant's nest, showing the graveled funnel, F, and the smooth nozzle, N. Page 32.

Fig. 15. Outline of the elevation of a formicary. Page 35.

Plate V.

Fig. 16. Double section view of the interior of a nest, drawn from a point in the excavation twenty-one inches below the surface. Nest made in soft, red sandstone. *g*, *g*, *g*, galleries arranged in stories. R, R, R, vertical sections through honey-rooms and chambers for nursery purposes. C, D, E, the floors of a suite of honey-rooms, showing their connection with the general system. Page 36.

Fig. 17. The three honey-rooms C, D, E, above referred to, and the indication of a fourth, F. Length of C from *a* to *b* = 5 inches; D, from *c* to *d* = $3\frac{1}{2}$ inches; E, from *e* to *h* = 4 inches. Elevation of *b* above *x* = $3\frac{1}{2}$ inches; of *b* above *e* = 6 inches. A little stairway united D with C and F; *g*, *g*, a gallery. Page 36.

Fig. 18. Section through middle of nest, showing the gate architecture. G, gate; N, nozzle; A, arm of the gate gallery terminating in the vestibule V. *a*, *b*, *c*, branching galleries. Page 32.

Fig. 19. A similar section of another nest. Letters as above; E, a small room, with gallery *f*, leading downward.

Fig. 20. Similar section of another nest. The main gallery branches to the right, and passes behind the gate, *b*, *b*, *b*, into room A. E, C, small bays or rooms; D, D, *ee*, curved and branched gallery on the same plane, with openings downward *g*, *g*, *g*. Page 33.

Fig. 21. A honey-room, HR; *g;* gallery leading into the gate gallery, G; *ug*, unbroken part of same; B, small bay-room. Page 34.

Fig. 22. Termination of excavated nest, 6 feet 10 inches from gate, 2 feet 5 inches below surface. *g g*, gallery entrance; C, Queen-room, 4 inches diameter. E, Small bay-room, apparently beginning of a chamber; *t g*, terminal gallery, running upwards as though the ants were in process of excavating a room resembling C. Page 36.

Fig. 23. Sloping section through middle of nest, showing relation of gate to the upper series of galleries and rooms. A, B, honey-rooms; *x*, *y*, *z*, main galleries; 1, 2, 3, side openings. Page 33.

Fig. 24. A honey-bearer regurgitating honey from her crop at the solicitation of hungry workers. Page 46.

Fig. 25. Sentinels on guard at the gate. Page 20.

PLATE VI.

Fig. 26. A queen dragged home by a worker. Page 38.

Fig. 27. A honey-bearer dragged and pushed by a worker-major and dwarf from a broken room into a gallery. Page 39.

Fig. 28. A honey-bearer under a "landslide," one worker looking on, curious but inactive, another on the clod at her toilet. Page 41.

Fig. 29. Queen surrounded by her "court" or body-guard of attendant workers. Page 38.

Fig. 30. Workers carrying a pebble up the mound.

Fig. 31. Honey-bearer partly buried alive under pellets brought up by mining workers. Page 40.

Fig. 32. Honey-bearer fallen from her perch, being cleansed by a worker, who reaches down from the wall. Page 40.

Fig. 33. Honey-bearer with (apparently) morbid abdomen. Page 58.

Fig. 34. Worker nurses feeding and cleansing larvæ. Page 43.

Fig. 35. View of vertical section of a nest, showing galleries arranged in stories. See Pl. V, fig. 16. G, location of gate; *a*—*t*, *e*—*i*, *k*—*l*, galleries; R, R, sections of honey-rooms. Page 36, and foot-note.

Fig. 36. A worker dragging a honey-bearer up a perpendicular surface into a gallery. Page 39.

Plate VII.

Fig. 37. View of the under side of the head of *Myrmecocystus hortus-deorum*, showing the mouth organs. × 20, Page 20.

The letter-references in this and subsequent anatomical figures are uniform throughout. The Key to References, therefore (p. 70), will apply to all figures.

Fig. 38. Face sculpture of same. × 20, Page 20.

Fig. 39. Side view of head of worker to show parasitic mites clinging thereto. The mites are about natural size. Page 63.

Fig. 40 Dorsal view of mites greatly enlarged.

Fig. 41. Ventral view of same.

Fig. 42. One of the suckers, *su*, contracted.

Figs. 43 and 44, the same further drawn out.

Fig. 45. Muscles of the honey crop, showing their netted and branched character. × 30, Page 54.

Fig. 46. The same, from margin of the crop. *C. ms*, crop muscles; *b. ms*, branched muscles.

Fig. 47. Third leg of *M. hortus-deorum*, worker-minor. × 10.

Fig. 48. Section of segmental plate of abdomen of honey ant, showing hexagonal cells of epithelium, and a bristle-like hair, or seta, arising therefrom.

Fig. 49. Profile view of segmental plates of *Camponotus inflatus*, showing the overlapping of the same, and the imbricated epithelial cells, forming a rachet-like structure which suggests the possibility of a sound-producing organism. *e. ab. pl*, exterior abdominal plate; *i. ab. pl*, interior ditto. Page 61.

Fig. 50. Profile view of abdominal plate of *M. hortus-deorum*, to show the same.

Fig. 51. After Lubbock. Section through the head of *Lasius niger*, to show site of buccal sac, *bc. s*, the pharynx, *px*, and its muscles, *p. ms.* × 36, Page 52.

Fig. 52. View of the œsophagus of a worker of *M. hortus-deorum.* One side of the thorax and petiole are cut away in order to show the œsophagus in site. × 18, Page 53.

Fig. 53. Abdomem of honey ant, showing the segmental plates both dorsal (D) and ventral (V) in normal condition of the crop. × 16, Page 53.

Fig. 54. Same, when separated by partly expanded crop. Page 53.

Plate VIII.

Fig. 55. Entire crop with gizzard and stomach. Dissected from a honey-bearer with morbid abdomen. × 14, Page 53.

Fig. 56. Crop, gizzard, stomach, malpighian tubes and intestine. From honey-bearer. × 14, Page 54.

Fig. 57. Enlarged view of gizzard. × 50, Page 55.

Fig. 58. After Forel. Topographic, somewhat diagrammatic representation of the organs opening into the cloaca of *Bothriomyrmex meridionalis* ♀, enlarged 18 times.

4, 5 and 6, optical section of the tergal chitinous pieces of what are really the 4th, 5th and 6th abdominal segments (nodes of the petiolus reckoned as one segment). Opposite and beneath there are shown the sterna of the corresponding segments. *do*, dorsal vessel; *an. v*, right anal vesicle; *an. gl*, right anal gland; *Can*, intestinal canal (intestine and rectum); *po. v*, poison vesicle with gland; *ac. gl*, accessory gland of the poison apparatus; *Ov*, rudimentary ovaries with vagina; *ab. g*, the last three abdominal ganglia of the ventral cord with their commissures.

Between 6 and the corresponding sternal plate (6′), lies a cleft (shown wide open in the figure) which leads into the cavity of the cloaca. In this cavity one finds, reckoning downwards from 6 to 6′:

1. *O*, the common opening of the anal vesicles. 2. *an*, anus (opening of rectum). 3. *r. st*, rudimentary sting, into which the poison vesicle opens, and then lower down, the accessory gland of the poison apparatus. 4. *o. sa*, opening of the rudimentary female sexual apparatus.

Fig. 59. Crop in normal condition, from a virgin queen. The junction, *jn*, of the abdomen with the petiole is bent over, showing

a part of the œsophagus as drawn from the petiole. The continuation of the same, *œ. c*, within the abdomen is shown; also the relation of gizzard to both crop and stomach. × 14, Page 53.

Fig. 60. View of the intestine from the posterior pole of the abdomen to the anus. × 35, Page 56.

Plate IX.

Fig. 61. Synthetic figure exhibiting the entire course of the alimentary canal, from mouth to anus. Page 56.

Figs. 62–70 compose a series illustrating the progressive distension of the crop from the normal condition to that of the honey-bearer. Page 56.

The series begins with Figs. 63 and 66, where the crop is normal; in fig. 66 the crop has shrunken after distension.

Fig. 64. Worker crop, half filling abdomen.

Figs. 62, 65. Workers-major, or semi-rotunds, with distension of crop still further advanced.

Fig. 67. Abdomen of a worker-minor, showing same process of distension.

Fig. 68. Abdomen of a honey-bearer, opened at the slit, *s*, to puncture the crop and exhibit by its shrinking away the fact that the crop fills the cavity of the abdomen. Page 57.

Fig. 69. Full crop of honey-bearer, with the lower part of the alimentary canal shown through the abdominal wall against which it is pressed, and evidently in healthy condition. Page 57.

Fig. 70. Abdomen of honey-bearer, the full crop pressing the gizzard, stomach, etc., into the cloacal cavity. Page 57–8.

Fig. 71. Abdomen of the Australian carpenter-ant, *Camponotus inflatus*, exhibiting the characteristic distension of *M. hortus-deorum*. Drawn from an alcoholic specimen. The figure is somewhat flattened by pressure; other abdomens in my possession are quite spherical. The gizzard, stomach (ruptured and stretched) and intestine are shown in the same relative position as in the honey ant. Page 58.

Plate X.

Fig. 72. Side view of honey-bearer, *M. hortus-deorum*. × 3.

Fig. 73. Dorsal view of same. × 3, Page 69.

Fig. 74. Honey-bearer of *Camponotus inflatus*, dorsal view × 3, Page 59.

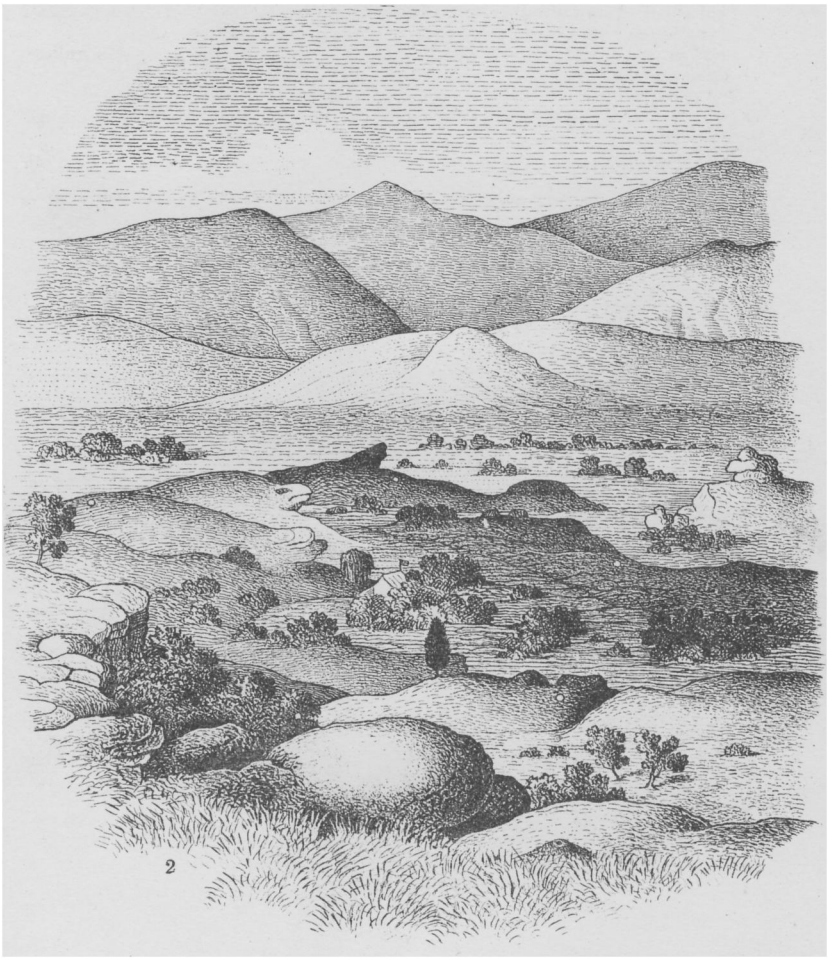
Figs. 75, 76. Male of *M. hortus-deorum*. × 5.

Figs. 77, 78. Winged female, or virgin queen of the same. × 3.

Fig. 79. Worker-minor of *M. hortus-deorum*. × 5. The workers-major and minor or dwarf are exactly similar in form, only longer in the proportions given in the description. Page 69.

Figs. 80, 81. Node or scale of the petiole queen of honey ant, side and front views. × 10.

Fig. 82. In part, after Swinton; to show the striæ, *str*, supposed stidulating organs, upon the junction of the abdomen and second node, 2. *nd*, and also on junction of second node with the first (1. *nd*,) of *Myrmica ruginodis*.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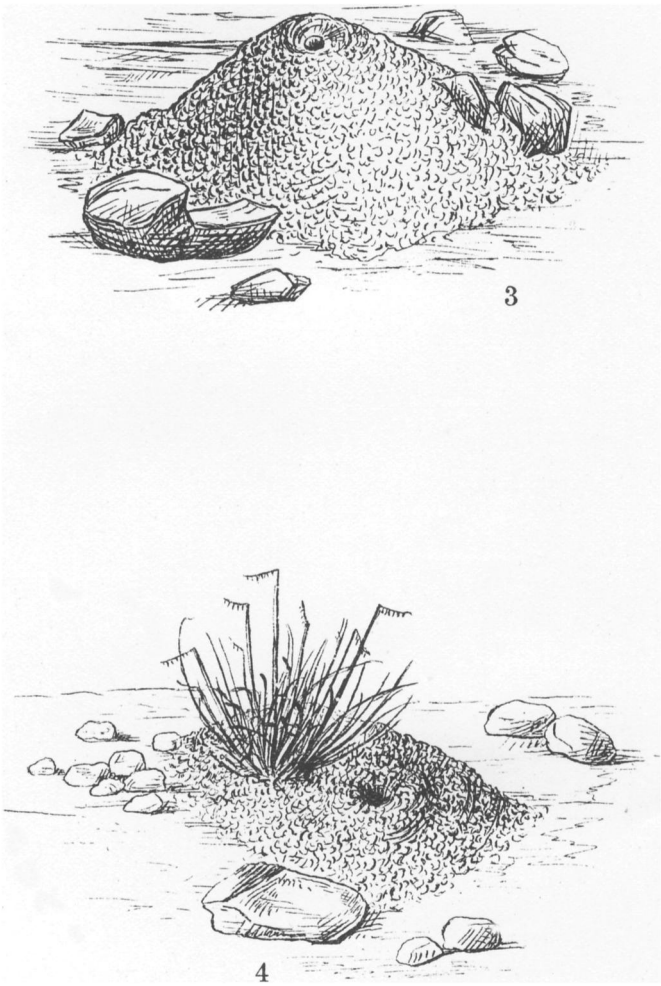

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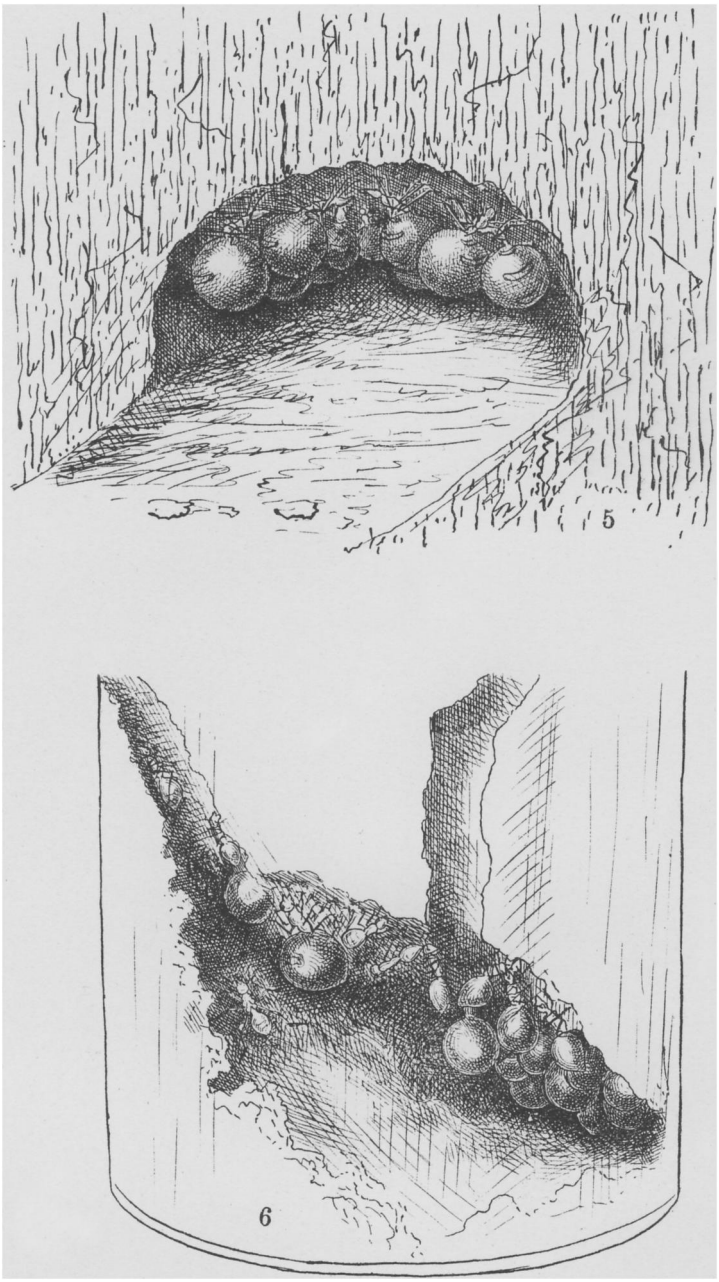
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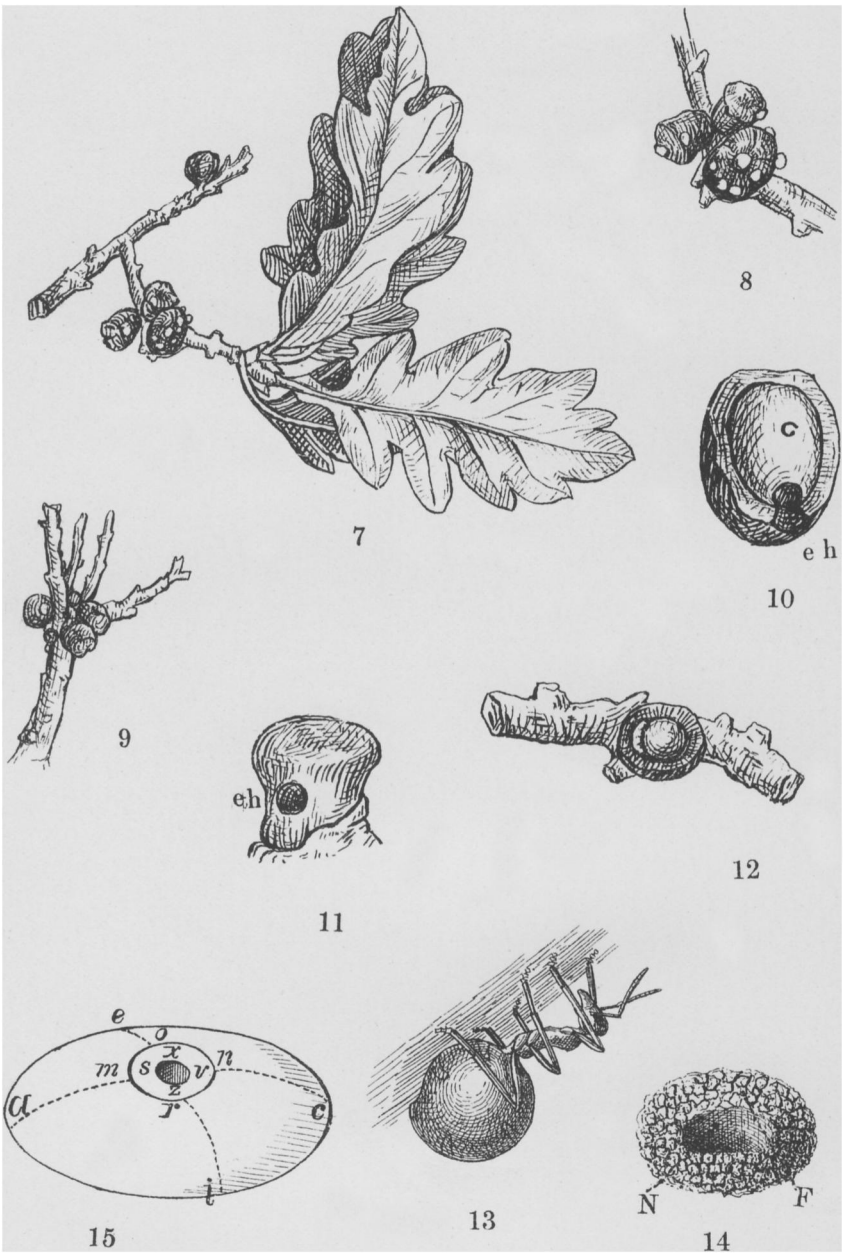
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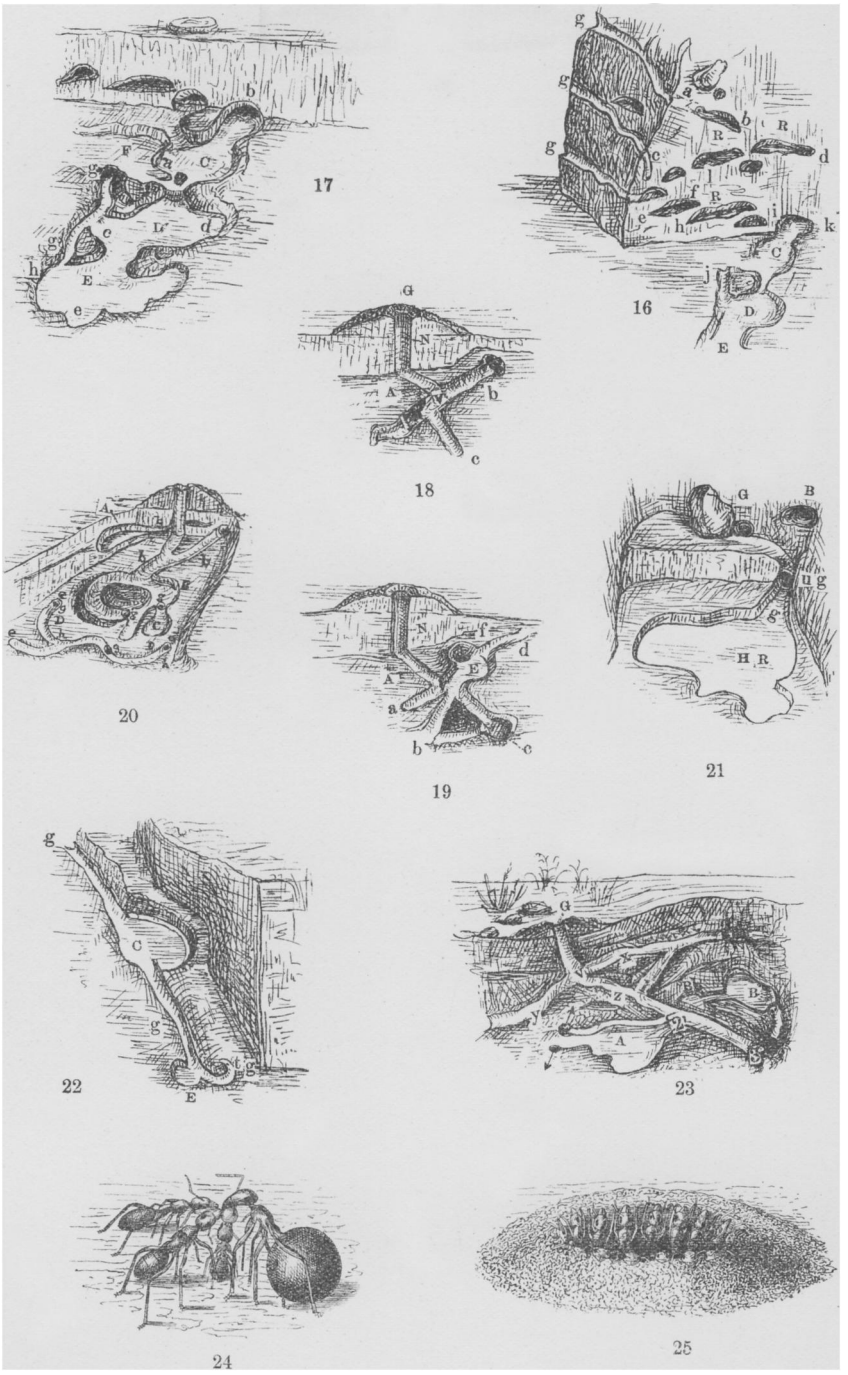
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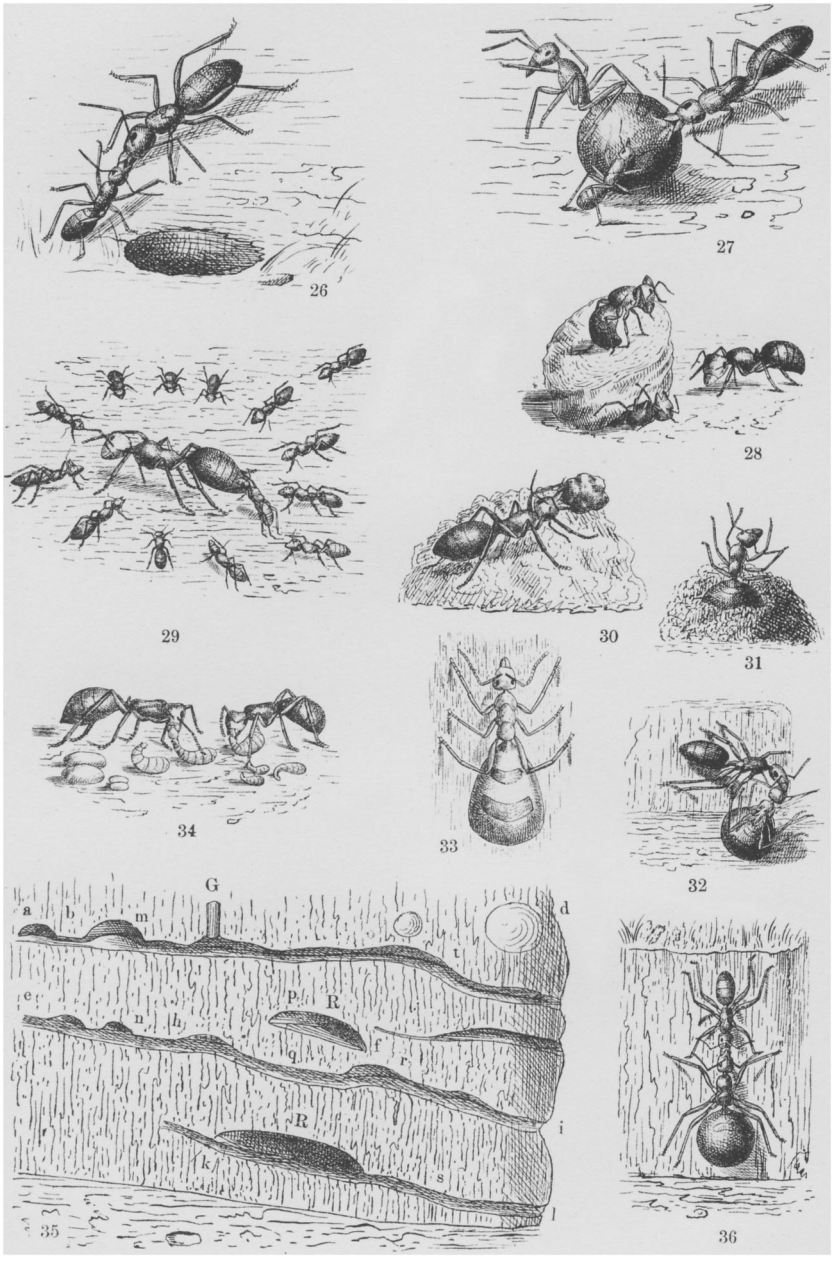
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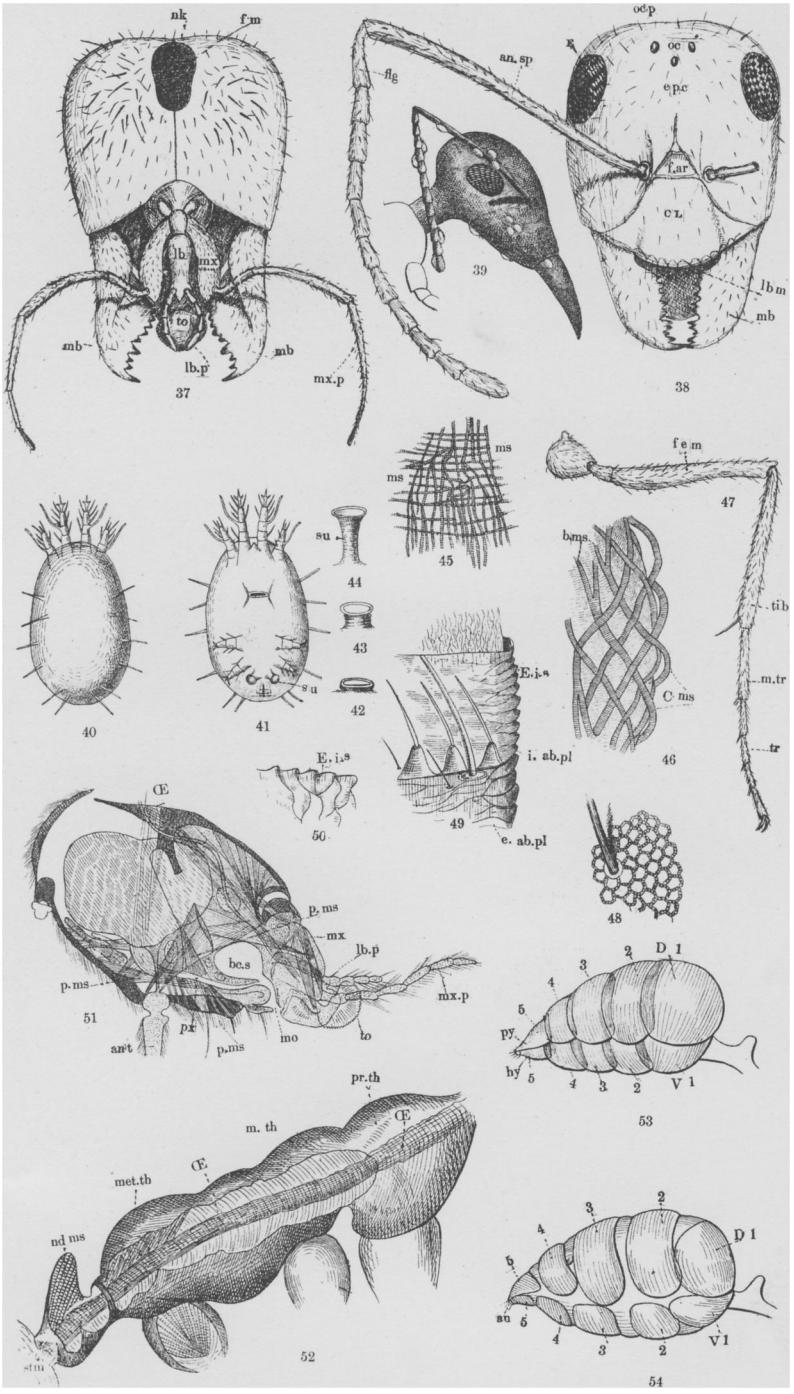
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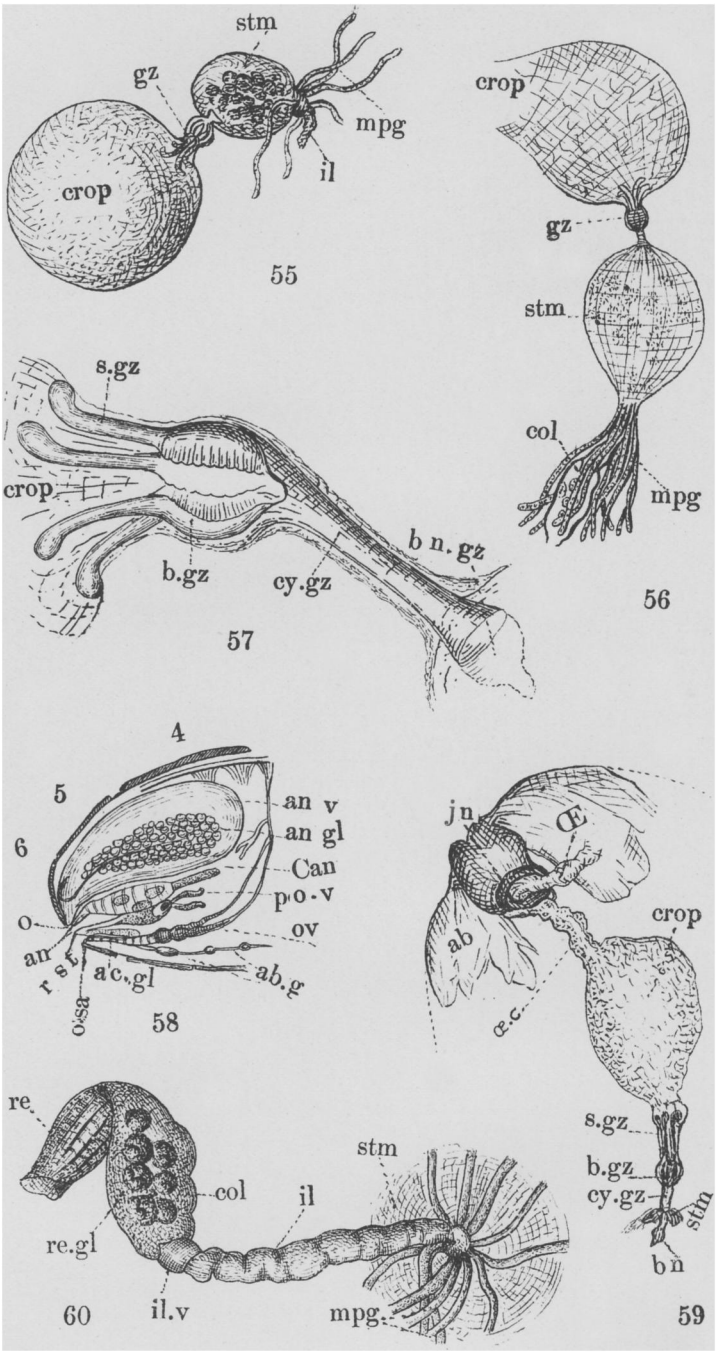
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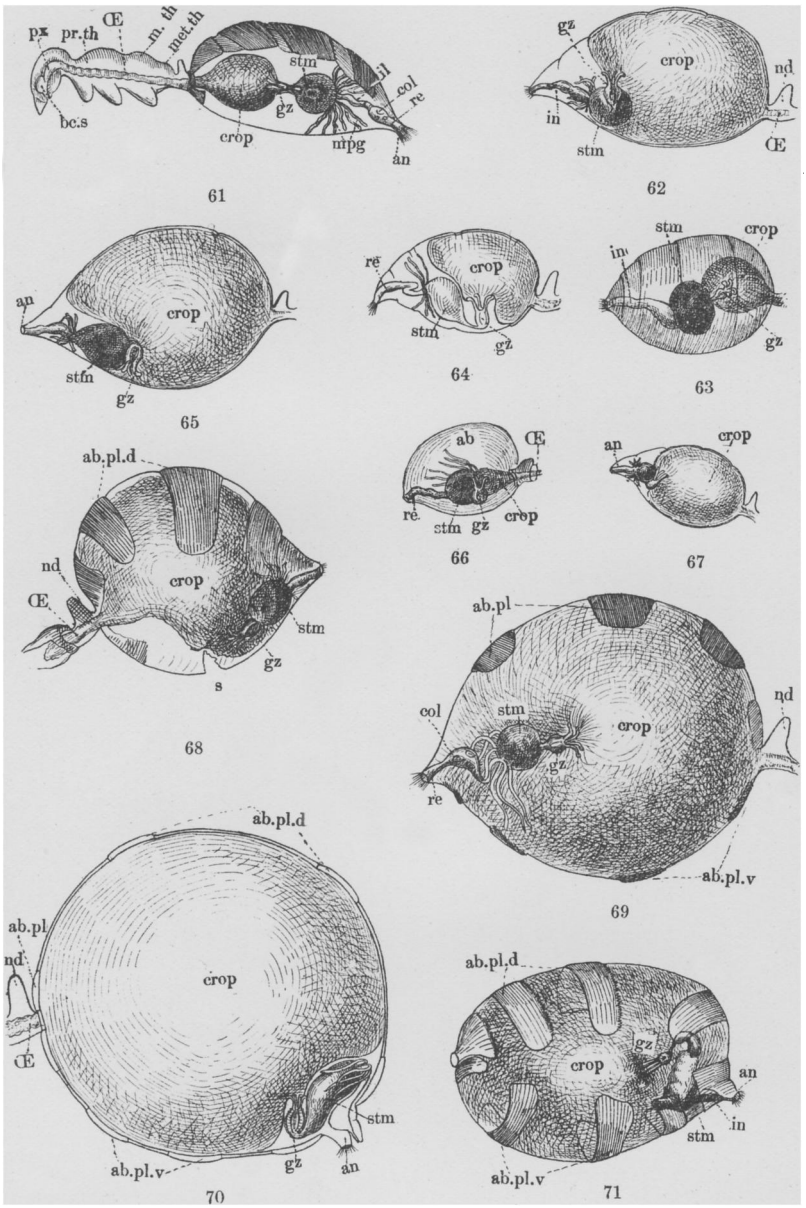
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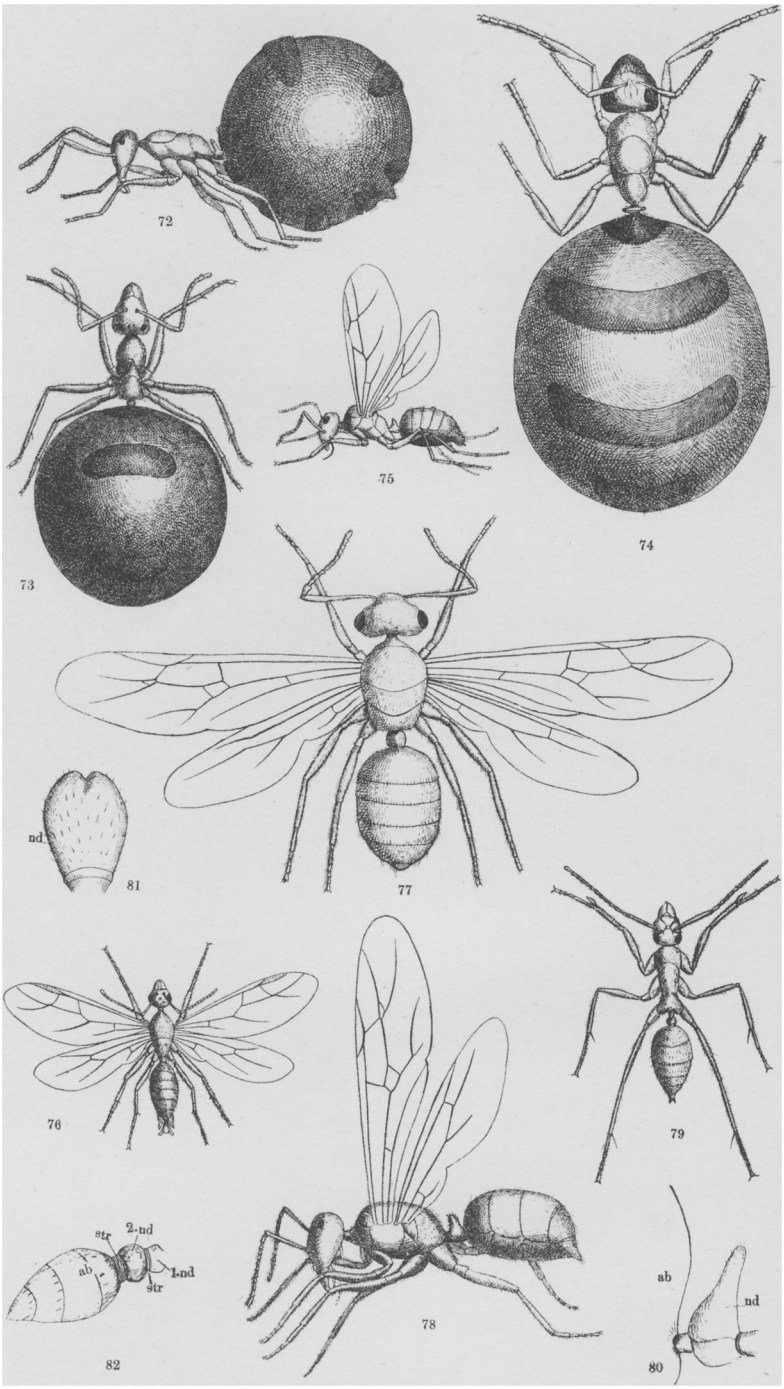
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